AIR QUALITY REPORT

FOR BRITISH COLUMBIA

Fine Particulate (PM_{10}) Levels

(1990-1995)

Ministry of Environment,
Lands and Parks

The Fine Particulate Series of Reports Published by the Air Resources Branch

Data Summary Report of REVEAL (REgional Visibility Experimental Assessment in the Lower Fraser Valley), September, 1994.

CMB Source Apportionment During REVEAL, September, 1994.

Visibility and Ambient Aerosols in Southwestern British Columbia During REVEAL, September, 1994.

Visibility and Ambient Aerosols in Southwestern British Columbia During REVEAL - Part 2. (Extension of the Source Apportionment of Ambient Aerosols During REVEAL), December, 1994.

Health Effects of Inhalable Particles: Implications for British Columbia, June, 1995.

Visibility and Ambient Aerosols in Southwestern British Columbia During REVEAL - Part 3. (Further Analysis of Visibility Data and Fine Aerosols Collected During REVEAL), July, 1995.

Visibility Perception in the Lower Fraser Valley, July, 1995.

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EXECUTIVE SUMMARY

Fine airborne particles called "PM_{10}" are considered the most important outdoor air pollutant in British Columbia today. They are a concern because they can be inhaled into the lungs, where they can remain for weeks to months before being removed by the body's natural defense mechanisms. Medical studies indicate that PM_{10} is associated with a variety of health effects, ranging in severity from increased coughing and school absenteeism, to a significant rise in the number of premature deaths.

PM_{10} consists of a mixture of particles of varied size, composition and origin. These particles originate from both natural and human-related activities. In addition, they are emitted directly to the atmosphere (*primary* particles) and produced in the atmosphere from chemical and physical processes involving various gases (*secondary* particles).

BC Environment has monitored PM_{10} levels at close to 100 sites in British Columbia since the mid-1980's. The current network consists of a mix of over 40 manual samplers and 20 continuous samplers. Manual samplers are typically operated for a 24-hour period once every six days. Continuous samplers provide real-time measurements every day of the year. Most data is forwarded to a central electronic database for storage.

This report marks the first overview of PM_{10} levels measured in various communities across the province. The assessment was limited to data collected between 1990-1995, and primarily to those sites exhibiting good data availability. Hence, sites with the worst or the best air quality in the province may not have been considered here. The following observations were drawn from these analyses:

- Annual mean concentrations ranged from less than $15\ \mu g/m^3$ to greater than $50\mu g/m^3$.

- Concentrations were highest at sites in the interior of the province and lowest at sites in southwestern British Columbia.
- Annual concentrations appear to be decreasing with time at a number of the sites investigated. However, it is premature to link these reductions to specific control strategies.
- Exceptions are found in Prince George and 100 Mile House, where concentrations have remained the same or appear to be increasing with time.
- The provincial air quality objective for PM_{10} is 50 $\mu g / m^3$. Few to no exceedances of the air quality objective were reported for sites in southwestern British Columbia. At sites in Prince George, Quesnel, Merritt and Golden, the objective was exceeded, on average, a minimum of 10% of the time between 1993-1995. This corresponds to more than 5 weeks per year that the air quality due to PM_{10} was considered poor or very poor.
- Large seasonal variations in PM_{10} levels were observed. The highest PM_{10} concentrations were typically observed during the winter months, and in particular, in February and March. Numerous factors may have contributed to these findings, including seasonal variations in emission sources and meteorological conditions.
- The number of 10 $\mu g / m^3$ increments of PM_{10} above a threshold level can be used to estimate the potential for associated health effects due to PM_{10}. Any non-zero increment indicates an increased risk of health effects. On an annual basis, the number of PM_{10} increments calculated for sites in British Columbia ranged from less than 10 to greater than 1000.

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1. INTRODUCTION

Fine airborne particles called "PM_{10}" have been identified as the single most important outdoor air contaminant in British Columbia today (Provincial Health Officer, 1994). They are a concern because they can be inhaled into the lungs, where they can remain for weeks to months before being removed by the body's natural defense mechanisms. Elevated levels of PM_{10} are associated with various health effects, ranging from increased respiratory symptoms to an increased risk of premature death. Dr. Sverre Vedal, a medical researcher at the University of British Columbia, has estimated the health impacts of ambient PM_{10} levels in this province (Vedal, 1995). They include an extra 82 deaths, 146 extra hospitalizations for lung and heart disorders and asthma, 283 extra emergency room visits for asthma, and over 165,000 extra absences from school each year.

Unlike other air contaminants such as carbon monoxide or ozone, which are pure substances, PM_{10} is a mixture of particles of varied size, composition and origin. By definition, PM_{10} refers to those particles that are 10 micrometres (μm) or smaller in diameter. A micrometre (μm) is one-millionth of a metre. Particles of this size can remain airborne for extended periods of time and tend to move around just like gases. The very fine particles can affect visibility as well as human health. They originate from both natural and human-related activities. Furthermore, they are emitted directly to the atmosphere (*primary* particles) and produced in the atmosphere from chemical and physical processes involving various gases (*secondary* particles).

The sources of PM_{10} vary from community-to-community and from season-to-season. Based on the 1990 provincial emissions inventory, an estimated 450 thousand tonnes of PM_{10} (primary particles) were released into the atmosphere that year (Stevenson, 1994). As summarized in Figure 1.1, forest fires and prescribed burning account for the majority (64%) of these emissions, and can have a large impact on *regional air quality*. Point sources such as pulp mills, sawmills, beehive burners and grain elevators account for a further 17%, and can affect *local air quality*. Smaller contributions

from area sources (e.g. wood stoves, fireplaces and backyard burning); mobile sources (e.g. diesel trucks); and road dust are also important to local air quality, as they are numerous and / or widespread and located in close proximity to where we live.

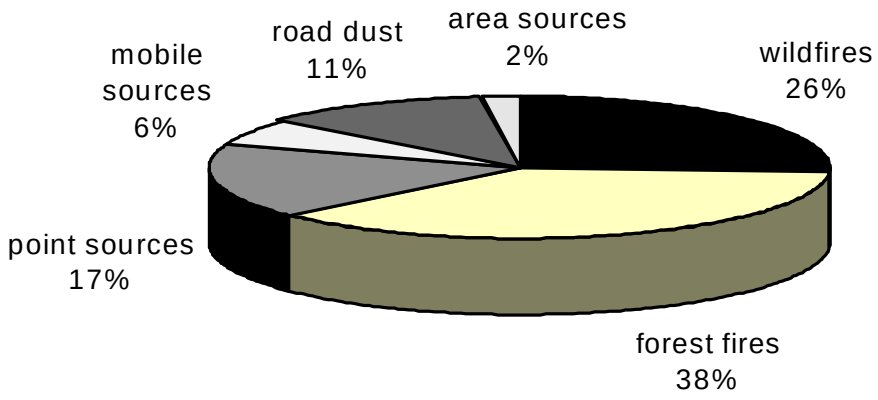


Figure 1.1 Summary of PM_{10} emissions in British Columbia (based on Stevenson, 1990).

Secondary particles were not considered in the emission inventory estimates, although studies limited to the Lower Fraser Valley indicate that they comprise up to 50% of the very fine PM_{10} particles collected during the summertime (Lowenthal et al., 1994; Pryor and Steyn, 1994). Sulphur dioxide (SO_2), nitrogen oxides (NOx), various hydrocarbons and ammonia (NH_3) are important gases involved in the formation of secondary particles. In the Lower Fraser Valley, major sources of SO_2 include the cement and petroleum industries, marine vessels and motor vehicles (ARB, 1994). Approximately 75% of the NOx emissions are from motor vehicles and marine vessels. Motor vehicles, solvent usage and vegetation contribute over 70% of the hydrocarbon emissions. Agriculture is the dominant source of NH_3.

BC Environment has implemented a number of programs to reduce the amount of PM_{10} emitted into the atmosphere. Regulations have been passed to reduce smoke

from land-clearing fires and wood stoves. A model bylaw has been developed to assist local governments in restricting backyard burning. Beehive burners are being phased out, beginning in the most smoke-sensitive areas of the province. To reduce emissions from the motor vehicle sector, the Province has adopted new gasoline and vehicle emission standards. AirCare, a vehicle emission maintenance and inspection program in the Lower Fraser Valley, remains a weapon in the fight against smog and the associated secondary particulates.

To characterize PM_{10} levels in British Columbia, BC Environment has been monitoring PM_{10} levels throughout the province for a number of years. While the earliest monitoring dates back to 1985, the large-scale monitoring effort began in 1989. Regional PM_{10} levels have been summarized for the Kootenay Region (Mignacca, 1995), the Skeena Region (Johnson, 1997), Prince George (Lamble and Fudge, 1996), Kelowna and Kamloops (Josefowich and Reid, 1996), the Cariboo Region (Plain, 1996) and the GVRD (1995). However, a province-wide review of ambient PM_{10} levels has not been carried out to date. Hence, this report marks the first opportunity to review ambient PM_{10} levels at various monitoring sites throughout the province. This review is limited to data collected between 1990-1995.

2. SAMPLING METHODOLOGY

PM_{10} represents only a fraction of the particulate matter found in the atmosphere. In order to measure PM_{10} levels, it is first necessary to remove that fraction of particulate matter that is larger than 10 µm. This is done using a sample inlet which is designed to have a *50% cutpoint* of 10 µm. This means that it collects 50% of all 10 µm particles, and rejects 50%. Hence, particles larger than 10 µm can be captured, but at progressively lower efficiencies. This is much like the human respiratory system, in that a large percentage (but not all) of particles greater than 10 µm are removed in the oral and nasal passages, and thereby prevented from reaching the lungs.

Two different techniques are currently used to measure PM_{10} in the provincial monitoring network. The manual method is the traditional method of measuring PM_{10}.

The continuous method, due to its ease of operation and ability to provide real-time measurements, is finding growing application throughout the province.

The manual sampler operates under the following principles. Air is drawn through a pre-weighed filter for a 24-hour period at a known flowrate. The filter is then removed and sent to a laboratory for analysis. The increase in filter mass, together with the sampling period and sampling flowrate, are used to calculate the 24-hour PM_{10} concentration, typically in units of micrograms per cubic metre ($\mu g / m^3$). Additional analyses can be performed on the filter to determine the chemical composition of the sample. Measurements are typically made once every six days. This coincides with the sampling schedule used in the National Air Pollution Surveillance (NAPS) network. Based on this schedule, a maximum of about 61 samples can be obtained in any year. This corresponds to annual coverage of about 17%. Two types of manual samplers are presently used in the provincial monitoring network: the size-selective inlet (SSI) high-volume sampler, and the Partisol™ sampler. A third type - the dichotomous sampler - is employed at NAPS sites in Victoria and Vancouver.

The continuous sampler used in the provincial network is the Tapered Element Oscillating Microbalance, or TEOM™. Its operating principles are as follows: Heated air is drawn through a small filter which sits on the end of a hollow, tapered tube. This tube is fixed at the other end, and therefore free to oscillate much like a tuning fork. As particles are collected on the filter, the mass of the filter changes. This will affect the rate at which the tube oscillates. The oscillation frequency of the tube is then used to estimate ambient PM_{10} levels. The TEOM™ instrument is expensive relative to other manual samplers, and there are some concerns that by heating the sample, some of the particle matter may *volatilize*, i.e. vaporize (Meyer et al., 1992). In addition, the basic setup does not allow for chemical analyses to be performed on the collected sample, as is available with the manual samplers. The advantages of the TEOM™ are that it can provide continuous measurements of PM_{10} levels, 365 days a year, and requires filter changes only once every two to four weeks.

3. QUALITY ASSURANCE

To ensure that the PM_{10} data collected in the province are scientifically acceptable and consistent throughout the province, Air Monitoring Guidelines have been prepared by BC Environment (ARB, 1996). The guidelines describe procedures for the siting, installation, operation and calibration of manual samplers. A similar set of guidelines for continuous samplers is expected in the near future. At present, no formal province-wide audit program exists for PM_{10} samplers, although samplers are regularly calibrated, maintained and operated by regional Ministry staff, contractors and permittees. It is expected that an audit program will be initiated in 1997.

Once a sample has been obtained, all filters from manual samplers must be sent to a laboratory for further analysis. To ensure that the proper techniques are used, the laboratory is required to follow a number of tests according to BC Environment standards.

Data from all manual and most continuous samplers are then forwarded to a central electronic database for storage. The data must meet a number of screening criteria before being accepted onto the database. This is done to ensure that only valid data are archived.

4. SAMPLING SITES IN BC

PM_{10} has been monitored at close to one hundred different sites in the province. The current sampling network consists of a mix of over 40 manual samplers and 20 continuous samplers. The names and locations of past and present PM_{10} samplers in the BC network are presented in Appendix I. Samplers are located in each of the eight regions and sub-regions of BC Environment, and also in the Greater Vancouver Regional District (GVRD). Additional monitoring in the province is conducted by the federal government and industry. Data included in this report are mostly restricted to that obtained from BC Environment and GVRD sites.

5. MEASURES OF AIR QUALITY

As a measure of the air quality in a region, contaminant levels are compared to *air quality objectives.* Air quality objectives are developed by environmental and health authorities to provide guidance for environmental protection decisions. They are based on scientific studies which consider the effects of the contaminant on such receptors as humans, wildlife, vegetation, and materials, as well as aesthetic qualities such as visibility.

A national objective for PM_{10} is currently being developed. Recommendations are expected in 1997. Recognizing the threat that PM_{10} poses to human health, BC Environment has established an air quality objective of 50 $\mu g / m^3$ (24-hour average). The selection of this number was based on the findings by Vedal (1993) on the effects of woodsmoke in BC. Vedal found that each 50 $\mu g / m^3$ increment in PM_{10} was associated with an increase in health effects ranging from respiratory symptoms to death. Exceedances of the air quality objective indicate reduced protection against associated health effects. Hence, one measure of PM_{10} air quality is the number or frequency of exceedances of the air quality objective.

Air quality objectives for PM_{10} and other common contaminants also form the basis of the Air Quality Index (AQI). The AQI is a scale used in parts of the province and elsewhere to determine if air quality is "good", "fair", "poor" or "very poor". At sites where numerous contaminants are monitored, the AQI reflects the concentration of the contaminant that is highest compared to its respective air quality objective. Where PM_{10} is the contaminant of concern, air quality can be described as shown in Table 5.1. Exceedances of the air quality objective for PM_{10} indicate that air quality may be poor or very poor.

Table 5.1 Description of the air quality index, based on PM_{10} measurements.

Air Quality Descriptor	Air Quality Index	PM_{10} Conc. (24-h) ($\mu g / m^3$)
good	≤ 25	≤ 25
fair	26-50	26-50
poor	51-100	51-100
very poor	> 100	> 100

An alternate approach to evaluating PM_{10} air quality is through the use of PM_{10} increments. Recent reviews of the health literature (Dockery and Pope, 1994; Vedal, 1995) suggest that PM_{10} causes health effects at levels as low as 20 $\mu g / m^3$ (i.e. below the current provincial air quality objective). Studies also indicate that each 10 $\mu g / m^3$ increase in PM_{10} above this level (a *PM_{10} increment*) is associated with a linear increase in various health effects, as summarized in Table 5.2. Hence, the number of increments provides an estimate of the increased risk that an individual may experience due to ambient PM_{10} levels in their community. Any number of increments above zero indicates an increased risk. The greater the number of increments, the greater the risk.

Table 5.2. Health impacts associated with each PM_{10} increment (Vedal, 1995).

Each PM_{10} increment is linked with:

- a 1.0% increase in total number of deaths
- a 3.4% increase in number of deaths due to respiratory problems
- a 1.4% increase in number of deaths due to cardiac problems
- a 0.8% increase in hospitalizations due to respiratory problems
- a 0.6% increase in hospitalizations due to cardiac problems
- a 0.7% increase in hospitalizations due to asthma
- a 2.3% increase in emergency visits due to chronic obstructive pulmonary disease
- a 3.4% increase in emergency visits due to asthma
- a 4.1% increase in days absent from school

6. EVALUATION OF PM_{10} LEVELS

Before discussing PM_{10} levels in BC, some explanation of the terminology is warranted. The following explains terms which are regularly used in this document:

- *data capture* - Data capture refers to the percentage of samples available in any specified period. For instance, if daily measurements are expected, and only 300 measurements are available, the data capture is 82%. Data capture is an important parameter because it reflects how representative the samples are for the period in question. For example, an annual average based on only one sample has little meaning. As noted previously, a limitation with the manual samplers is that they are typically operated every sixth day. Hence, they provide coverage for a maximum of 17% of the year.
- *mean* - Also known as the average, it is defined as the sum of the data, divided by the number of available data. Over any time period, an actual measurement may fall below or above the mean concentration.
- *maximum* - The maximum refers to the peak concentration. It is generally representative of extreme rather than typical conditions. For this reason, it is not a good indicator of long-term changes in air quality. However, together with the mean concentration, it does describe the range of upper values.
- *exceedance frequency* - This gives a measure of how often the air quality objective (50 $\mu g / m^3$ for PM_{10}) is exceeded. For instance, if the objective is exceeded two times out of ten, the exceedance frequency is 20%.
- *PM_{10} increment* - In the current context, it is defined as the number of 10 $\mu g / m^3$ increments in ambient PM_{10} concentrations, beginning at 10 $\mu g / m^3$ above 20 $\mu g / m^3$ (i.e. at 30 $\mu g / m^3$). The first increment starts at 30 $\mu g / m^3$, the second increment at 40 $\mu g / m^3$, and so on. The number of PM_{10} increments provides an estimate of the increased risk that an individual experiences due to ambient PM_{10} levels. The risk increases linearly with the number of increments.

In Section 7, the above parameters will be used to describe PM_{10} levels at selected sites in the province.

7. PM_{10} LEVELS IN BC

The following is an overview of PM_{10} levels between 1990-1995 at selected stations within each of the eight regions and sub-regions of BC Environment and the GVRD. Site selection was based on data availability and, where more than one monitor was located in a community, on how well the site represented conditions throughout the community. Dichotomous sampler sites in the NAPS network were not included in this analysis.

All available data between 1990-1995 were used. In the case of some of the manual samplers, sampling was conducted at intervals other than the NAPS schedule (i.e. once every six days) to investigate special events such as forest fires, when PM_{10} levels are expected to be very high. In such cases, the annual statistics may be biased on the high side.

For each of the selected sites, a page of summary graphs is provided. Unless specified otherwise, all available data are plotted against time. Mean and maximum PM_{10} concentrations, on both an annual and monthly basis, are presented. To evaluate current and historical PM_{10} levels, annual exceedance frequencies and the number of annually adjusted PM_{10} increments are also provided. This data is further summarized in tabular form in Appendix II.

Where data capture is less than 75%, the year in question is identified by an asterisk in the figures, and by italicized text in Appendix II. Care should be exercised in drawing conclusions based on partial datasets.

Although each monitoring station meets a set of minimum siting criteria set out by BC Environment, local differences exist for a number of factors which will affect measurements: proximity to sources of PM_{10}, local landuse types, topography and meteorological conditions. Hence, care should also be exercised in extending

information from one point to an entire community, and in comparing measurements from one community to another.

Based on the available data from the selected stations, annual mean PM_{10} concentrations varied from 11 to 54 $\mu g / m^3$. Some sites recorded no exceedances of the air quality objective for PM_{10}, while one site recorded a maximum exceedance frequency of over 38%. The number of annually adjusted PM_{10} increments ranged from less than 10 to greater than 1000. Any increments greater than zero suggest an increased risk of health-related effects.

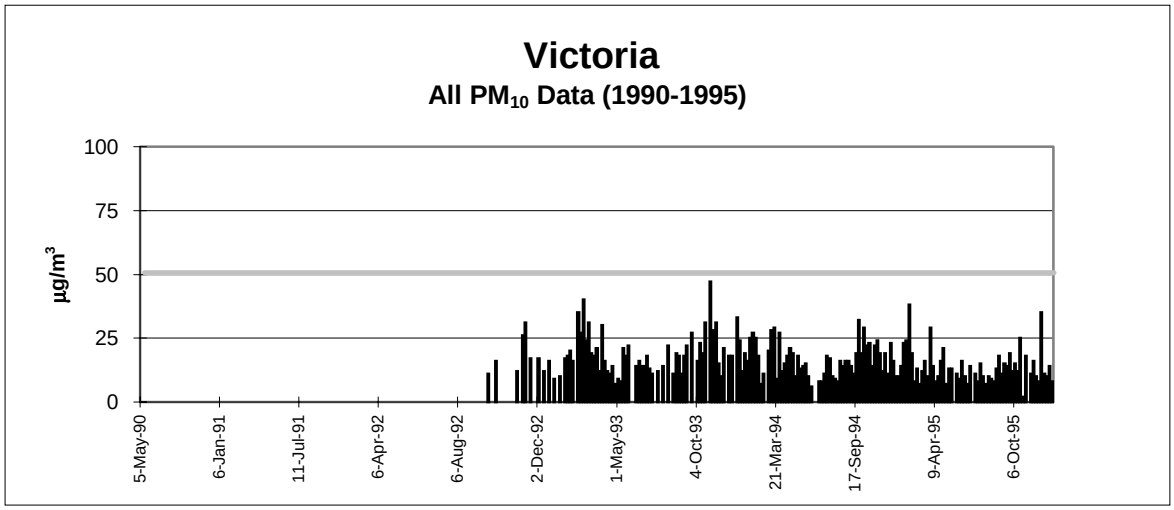
7.1 VANCOUVER ISLAND REGION

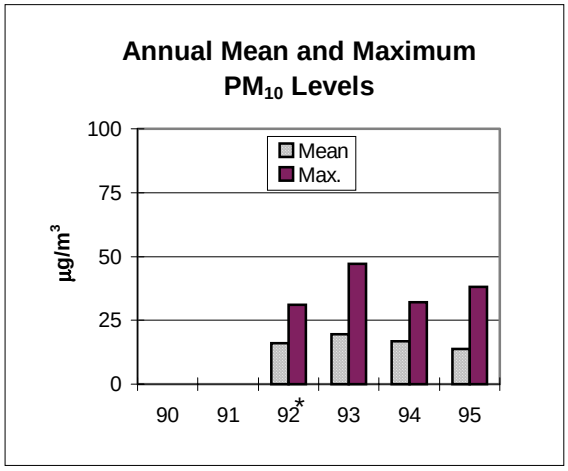
PM_{10} monitoring in the Vancouver Island Region has been carried out in Victoria, Port Alberni, Crofton, Harmac, Elk Falls and Gold River. The current network includes sites in Victoria, Port Alberni and Elk Falls. The following analyses focus on data collected at the Victoria and Port Alberni (Courthouse) monitoring sites.

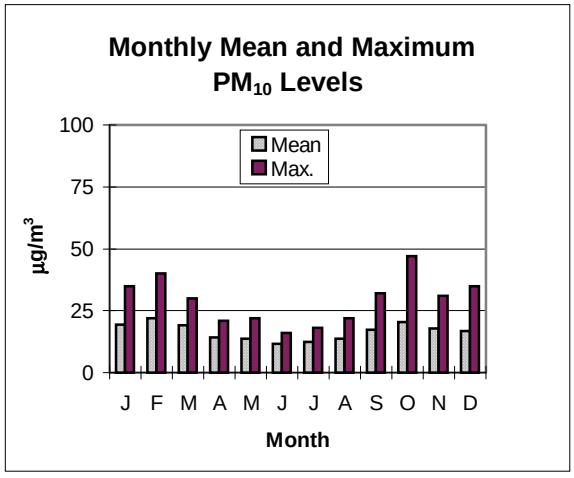
7.1.1 Victoria

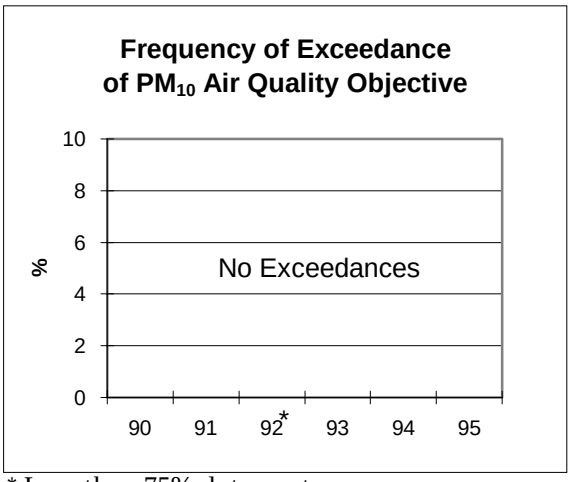
While limited PM_{10} monitoring in Victoria was carried out as early as 1988, regular monitoring did not begin until October 1992. Data from 1992 onwards are summarized on an annual and monthly basis in Figure 7.1 and in Appendix II. Data capture at this site has been satisfactory over the past three years. Relative to most other areas of the province, PM_{10} levels have been low. Between 1993-1995, no exceedances of the air quality objective were recorded. Mean PM_{10} concentrations decreased from 20 to 14 $\mu g / m^3$ during this period. The number of PM_{10} increments decreased from 66 in 1993 to 7 and 13 increments in 1994 and 1995, respectively. However, while these numbers are low, they still represent an increased risk of health effects due to PM_{10}.

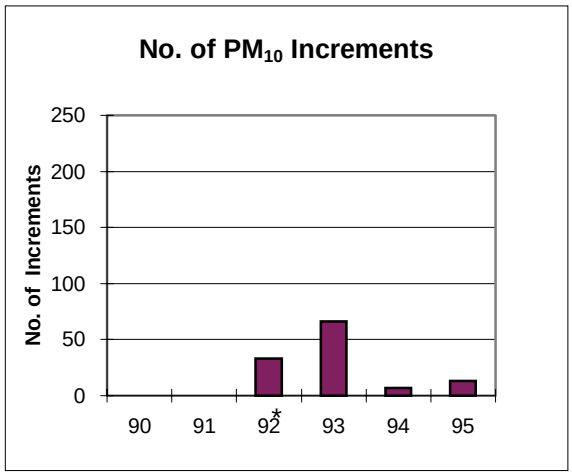
On a monthly basis, the highest mean concentrations were found in February (22 $\mu g / m^3$) and October (20 $\mu g / m^3$) and the lowest levels in April-August (12-14 $\mu g / m^3$). The highest concentration measured at this site was 47 $\mu g / m^3$ in October 1993.





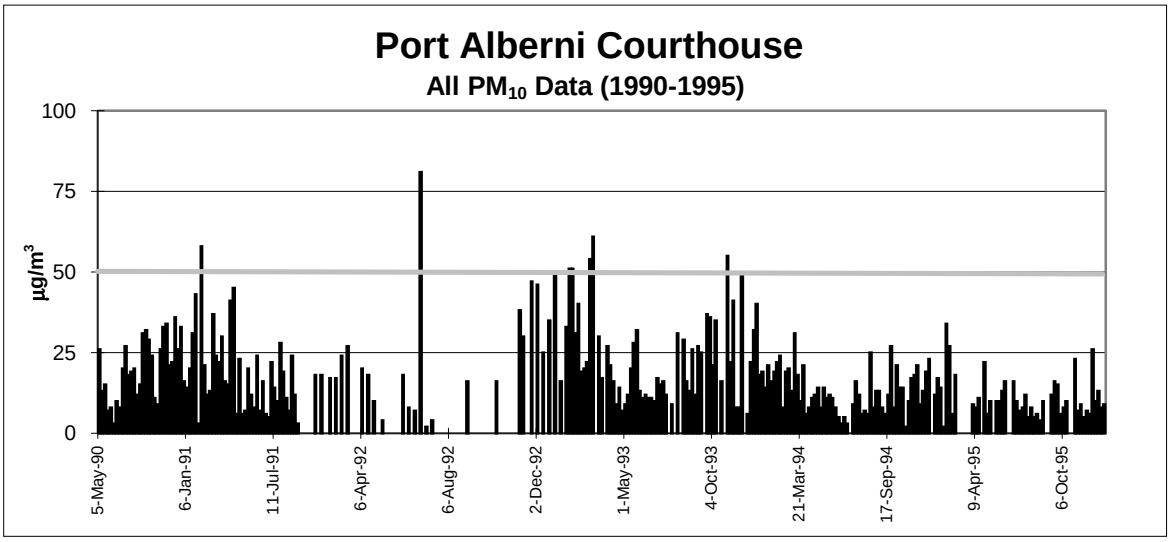


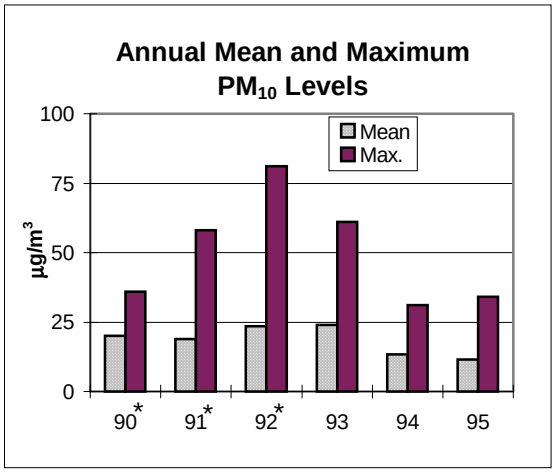


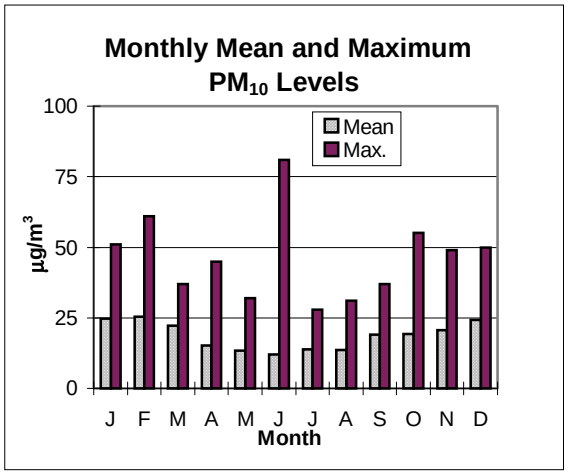


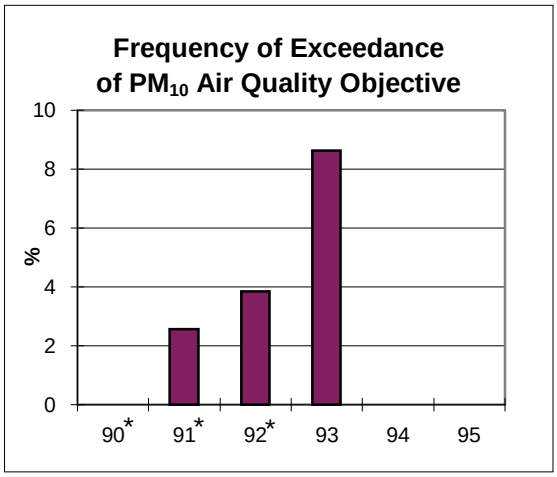
* Less than 75% data capture.

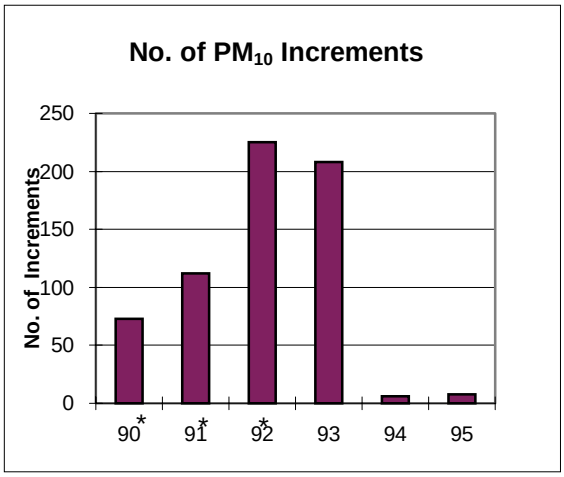
Figure 7.1 Summary of annual and monthly PM_{10} statistics, Victoria.











* Less than 75% data capture.

Figure 7.2 Summary of annual and monthly PM_{10} statistics, Pt. Alberni.

7.1.2 Port Alberni (Courthouse)

The Courthouse site is one of the oldest monitoring sites for fine particulates in the provincial network, with measurements dating back to February 1985. Reflecting the previous definition for "inhalable particulates," the early measurements are believed to be for PM_{15}, i.e. particles 15 μm and smaller in diameter. The current analysis is restricted to data from 1990 onwards, which are known to represent PM_{10}. Data are summarized on an annual and a monthly basis in Figure 7.2 and in Appendix II.

Data capture has been satisfactory since 1993. PM_{10} levels at this site have been very low relative to other areas of the province, particularly over the past two years. In 1994 and 1995, no exceedances of the air quality objective for PM_{10} were reported. Mean concentrations ranged from 11-13 $\mu g / m^3$. The number of annual PM_{10} increments was less than 10, which is a significant decrease from the over 200 increments estimated for 1993.

On a monthly basis, mean PM_{10} concentrations were highest in December-February (24-25 $\mu g / m^3$) and lowest during April-August (12-15 $\mu g / m^3$). The maximum recorded concentration was 81 $\mu g / m^3$ in June 1992. Exceedances of the air quality objective were observed during the months of January-February, June and October.

7.2 LOWER MAINLAND REGION

PM_{10} has been monitored at several locations within the Lower Mainland Region. The current provincial network consists of four manual samplers at Pitt Meadows, Albion, Mission and Hope, and three continuous monitors at Squamish, Abbotsford and Chilliwack. Additional monitoring is done by permittees in Langdale, Gibsons and Powell River. Data from sites in Pitt Meadows, Abbotsford and Hope are discussed in the following.

7.2.1 Pitt Meadows

A manual sampler began operating at the Pitt Meadows Airport in February 1991. Data from this site are summarized on an annual and monthly basis in Figure 7.3 and in Appendix II.

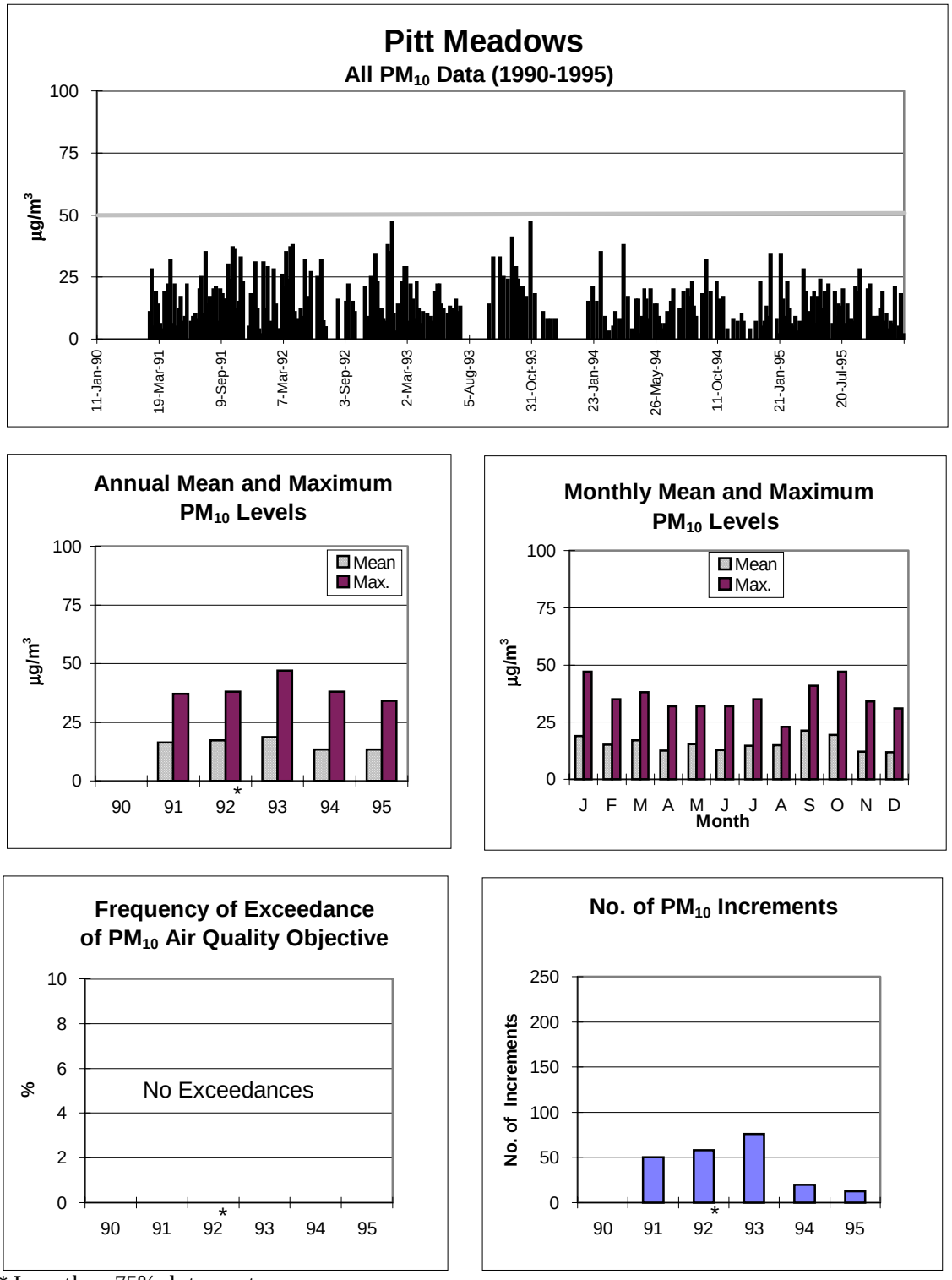
Data capture has been satisfactory, with the exception of 1992 when it was marginal. PM_{10} levels have been very low at this site, with no exceedances of the air quality objective observed to date. PM_{10} air quality has been particularly good over the past two years, reflected by annual concentrations of only 13 $\mu g / m^3$ and PM_{10} increments of no greater than 20. However, it is unclear whether these apparent improvements are due to reduced emissions or other factors.

On a monthly basis, the highest mean PM_{10} concentrations were found in September-October and January (19-21 $\mu g / m^3$) and the lowest levels in November-December (12 $\mu g / m^3$). The highest concentration observed at this site was 47 $\mu g / m^3$ in January and October 1993.

7.2.2 Abbotsford

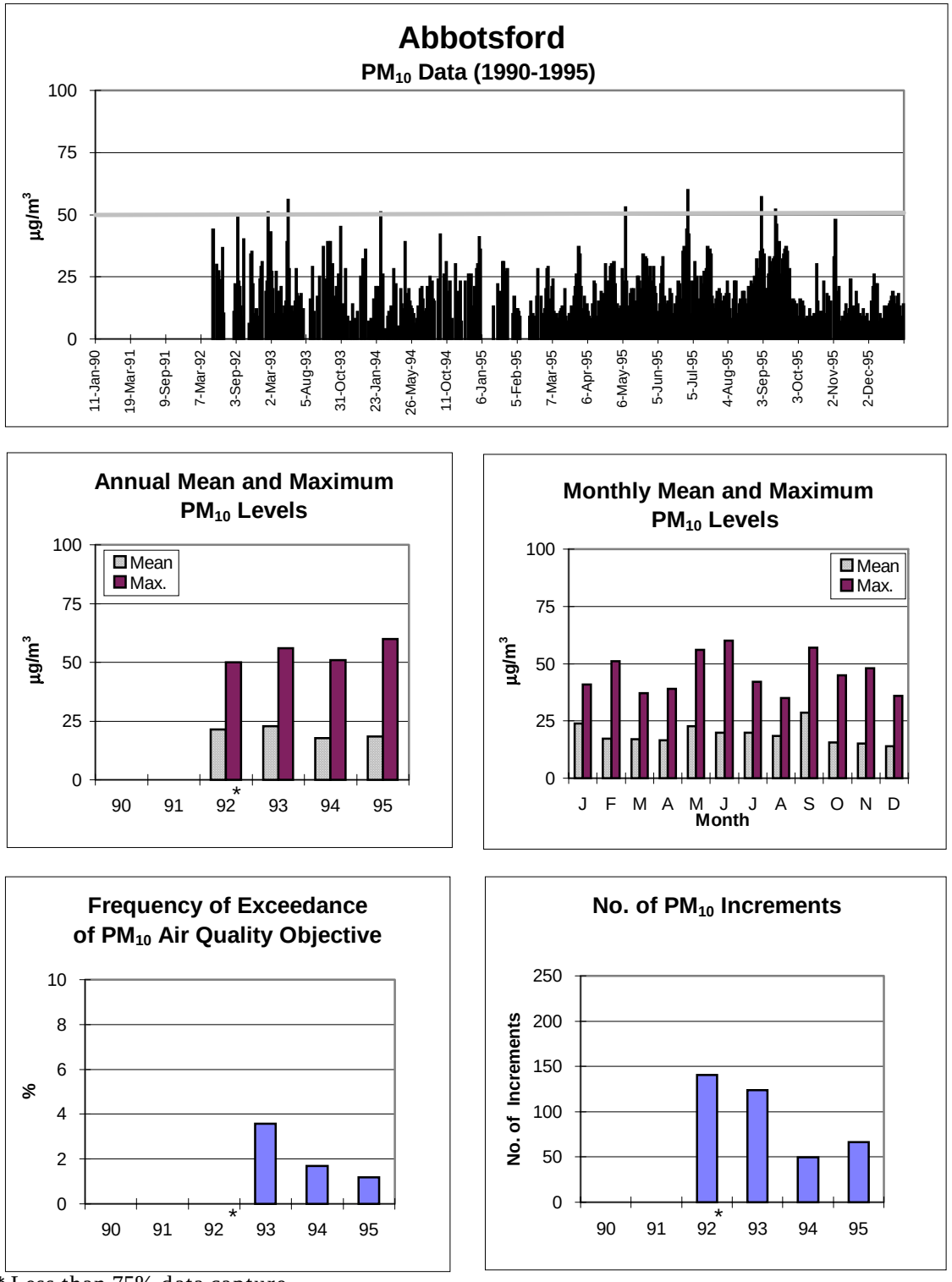
A manual sampler was installed on top of the Abbotsford Library in May 1992, and was shut down in March 1995. Current PM_{10} measurements are from a continuous sampler which was installed in July 1994. Data from this site are summarized on an annual and a monthly basis in Figure 7.4 and in Appendix II. Data shown prior to 1995 are from the manual sampler, while more recent data are from the continuous sampler.

Data capture at this site has been satisfactory over its three full years of operation (1993-1995). During this period, mean concentrations decreased from 23 to 18 $\mu g / m^3$, while exceedance frequencies fell from about 4% to 1%. The number of PM_{10} increments, which reflect an increased risk of health effects due to PM_{10}, fell from 124 in 1993 to less than 70 in 1994 and 1995. Although PM_{10} levels at this site are low relative to many other areas in the province, they are high relative to other parts of the Lower Mainland Region. On a monthly basis, the highest mean concentrations were found in September (29 $\mu g / m^3$) and January (24 $\mu g / m^3$) and the lowest levels in October-



* Less than 75% data capture.

Figure 7.3 Summary of annual and monthly PM_{10} statistics, Pitt Meadows.



* Less than 75% data capture.

Figure 7.4 Summary of annual and monthly PM_{10} statistics, Abbotsford.

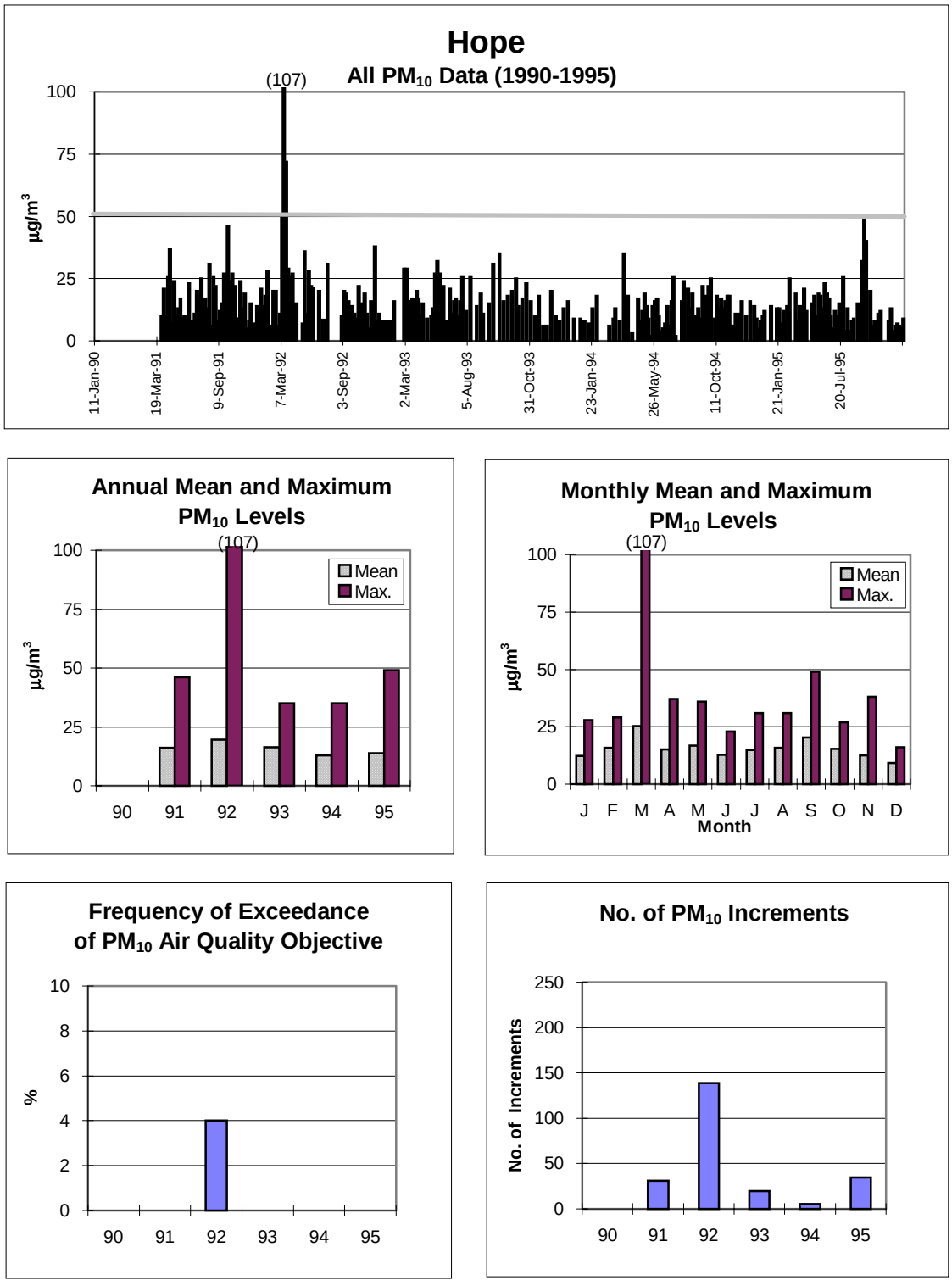


Figure 7.5 Summary of annual and monthly PM_{10} statistics, Hope.

December (14-16 $\mu g / m^3$). The highest observed concentration was 60 $\mu g / m^3$ in June 1995. Exceedances were limited to the months of February, May-June and September.

7.2.3 Hope

A manual sampler was installed at the Hope Firehall in March 1991. Data from this site are summarized on an annual and monthly basis in Figure 7.5 and in Appendix II. Data capture over the past five years has been acceptable. With the exception of 1992, no exceedances of the air quality objective have been measured at this site. PM_{10} levels have fluctuated from year-to-year, with the lowest mean concentrations occurring in 1994 and 1995 (13-14 $\mu g / m^3$). The number of PM_{10} increments, which reflect an increased risk of health effects due to PM_{10}, ranged from 5-34 over the past two years.

On a monthly basis, the highest mean PM_{10} concentrations were found in the months of March (25 $\mu g / m^3$) and September (20 $\mu g / m^3$), and the lowest levels in December (9 $\mu g / m^3$). The highest concentration recorded at this site was 107 $\mu g / m^3$ in March 1992, the only month during which an exceedance of the air quality objective was observed.

7.3 GVRD

The current GVRD PM_{10} monitoring network includes two manual samplers and eight continuous samplers spread among eight different sites throughout the region. The first manual samplers began operating in October 1989, while the first continuous samplers date back to October 1993. Data from the following sites will be discussed: Kitsilano (Vancouver); Rocky Point Park (Pt. Moody); and Surrey.

7.3.1 Kitsilano

The Kitsilano site is located in a suburban setting on the west side of Vancouver, at the Kitsilano Senior Secondary School. A manual sampler began operating at this site in July 1991. A continuous sampler was added in December 1993. Data are summarized on an annual and monthly basis in Figure 7.6 and in Appendix II. Data prior to 1994 are from the manual sampler. Data from 1994 onwards are from the continuous sampler.

Data capture at the Kitsilano site has been satisfactory over its four full years of operation (1992-1995). Relative to other areas of the province, PM_{10} levels at this site have been very low, and appear to have decreased over the past few years. Mean concentrations were 18-21 $\mu g / m^3$ in 1992-1993, and only 15 $\mu g / m^3$ in 1994-1995. The number of PM_{10} increments, reflecting an increased risk of health effects due to PM_{10}, dropped from greater than 45 to less than 15 over the same interval.

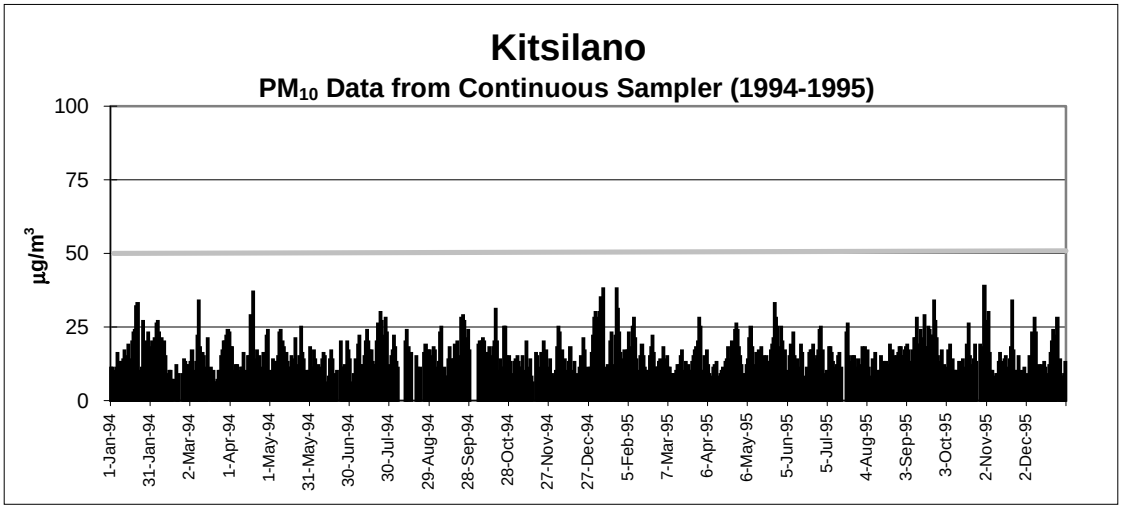
On a monthly basis, the highest mean PM_{10} concentrations were observed in January (21 $\mu g / m^3$), and the lowest levels in March-August (14-15 $\mu g / m^3$). The only exceedances ever observed at this site occurred in January 1993. The maximum concentration was 58 $\mu g / m^3$.

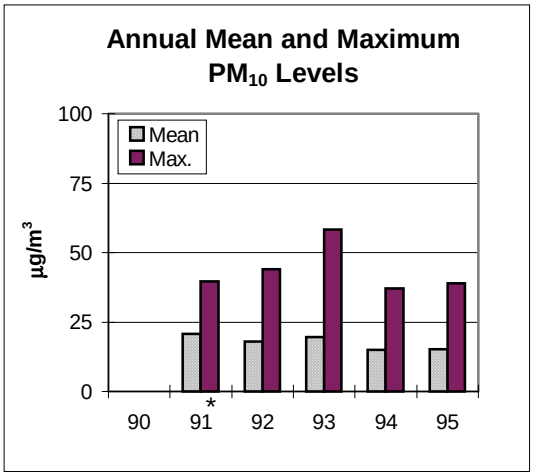
7.3.2 Port Moody

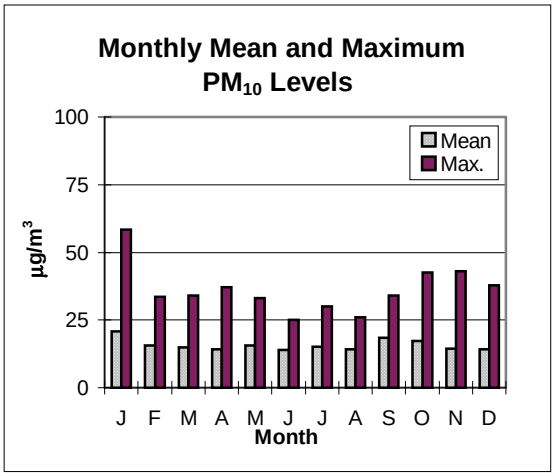
A manual sampler was installed in Rocky Point Park, Port Moody in March 1990, and a continuous sampler was added in November 1993. Data are summarized on an annual and monthly basis in Figure 7.7 and in Appendix II. Data prior to 1994 are from the manual sampler, and data from 1994 onwards are from the continuous sampler.

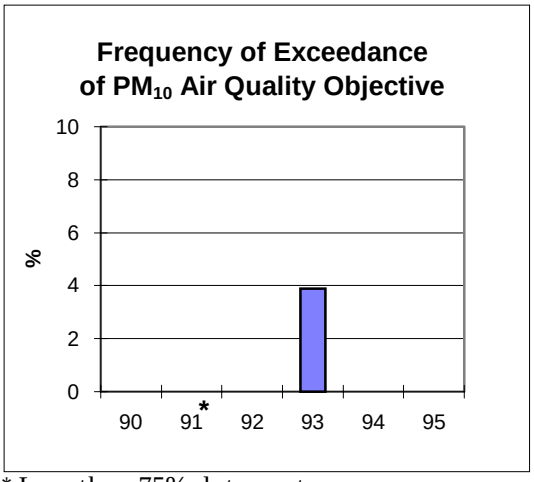
Data capture at this site has been satisfactory. PM_{10} concentrations have been low relative to many other areas of the province, particularly over the past two years. In both 1994 and 1995, the mean concentration was 17 $\mu g / m^3$ and the maximum concentration was 39-40 $\mu g / m^3$. No exceedances of the air quality objective were recorded. The number of annual PM_{10} increments, representative of increased health risks due to PM_{10}, was less than 25 both years.

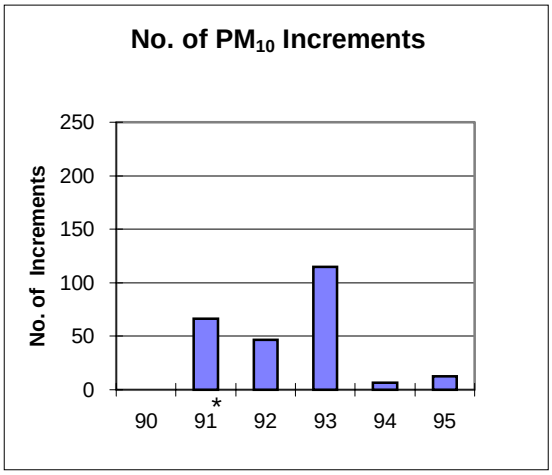
On a monthly basis, the highest mean concentrations were observed in January and September (22-23 $\mu g / m^3$), and the lowest concentrations in December (13 $\mu g / m^3$). The highest measurement at this site was 53 $\mu g / m^3$ in April 1991. Exceedances of the air quality objective were limited to the month of April.











* Less than 75% data capture.

Figure 7.6 Summary of annual and monthly PM_{10} statistics, Kitsilano.

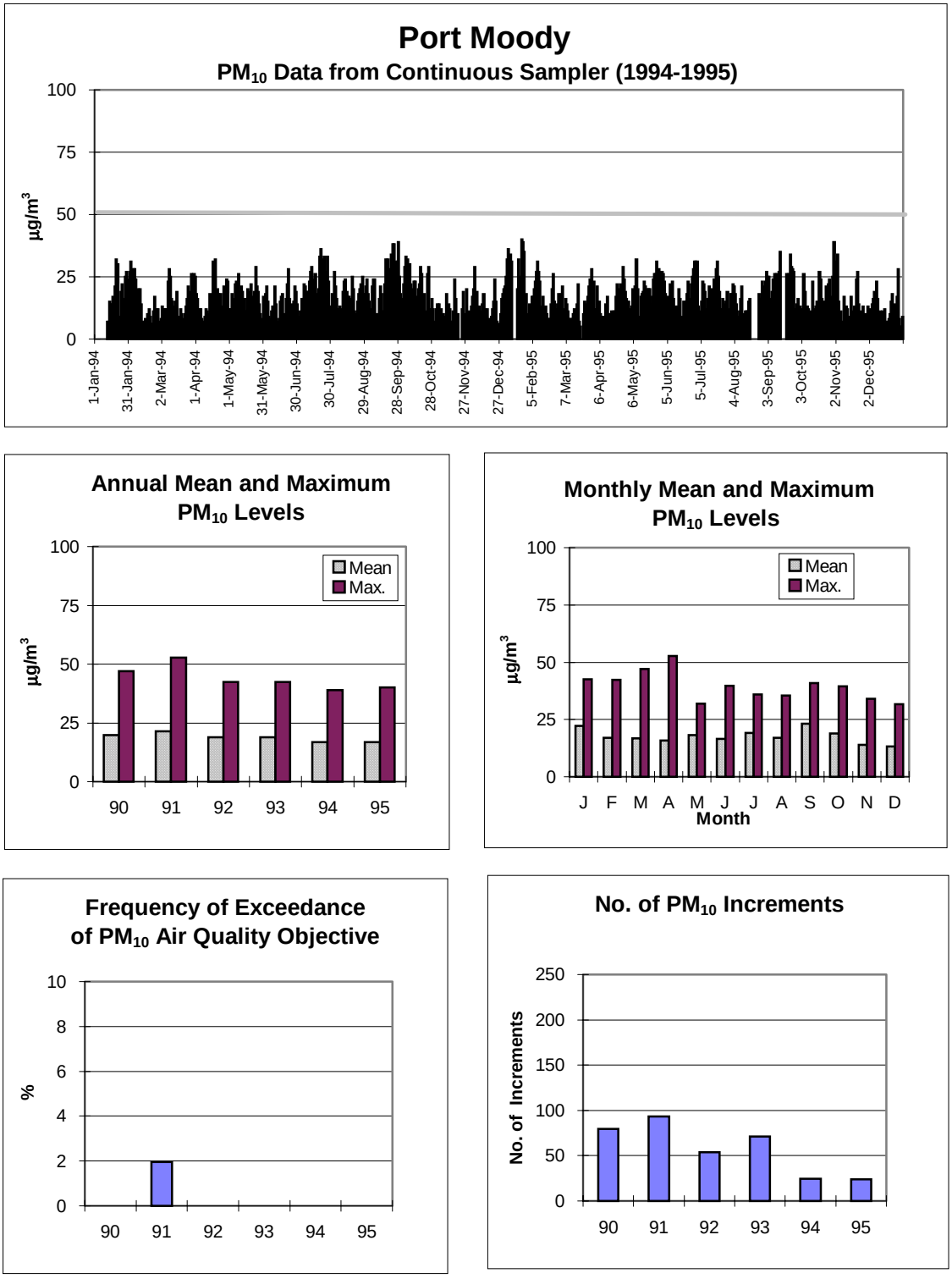


Figure 7.7 Summary of annual and monthly PM_{10} statistics, Port Moody.

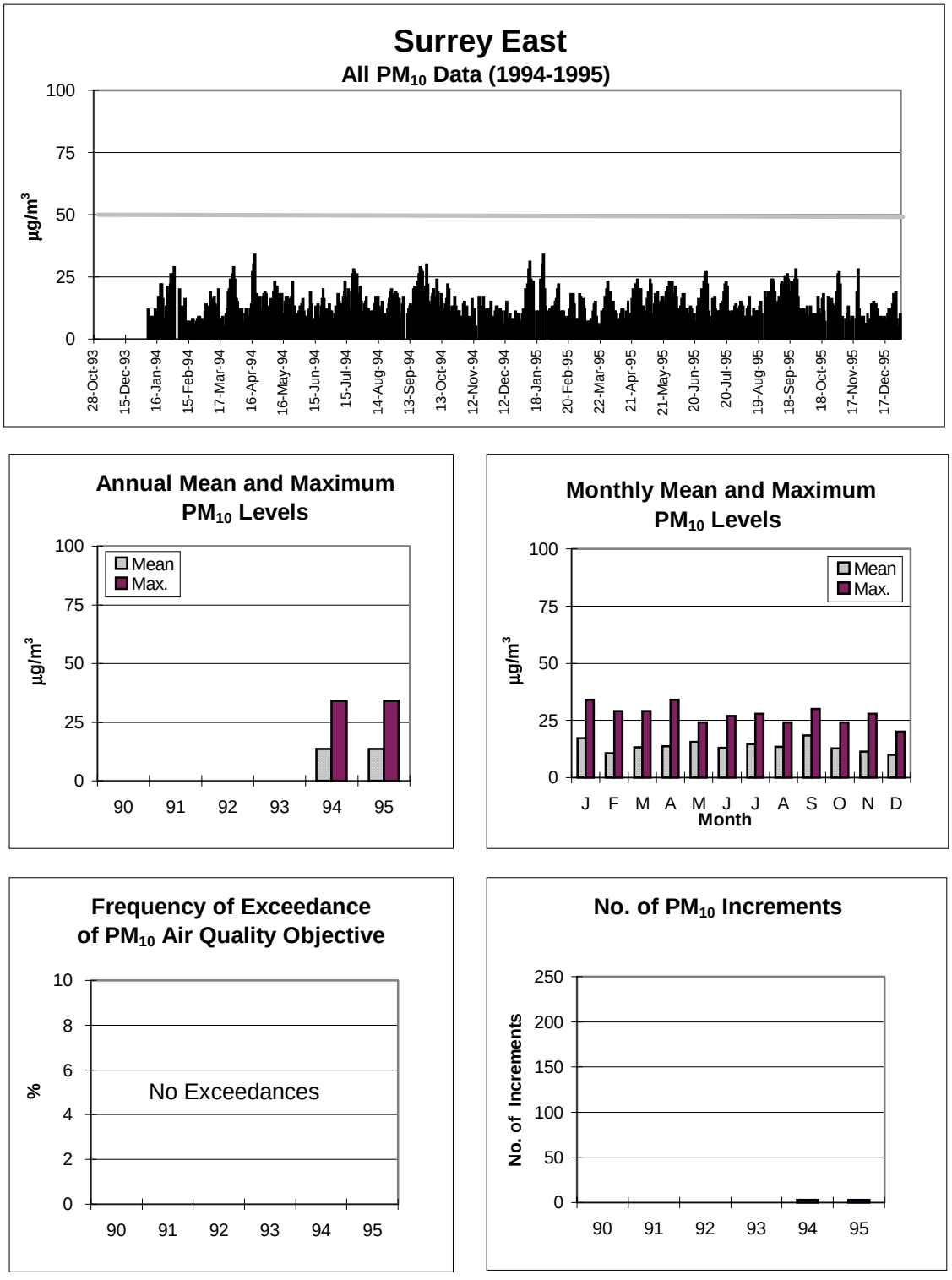


Figure 7.8 Summary of annual and monthly PM_{10} statistics, Surrey.

7.3.3 Surrey

A continuous sampler began operating at the Surrey East site in January 1994. Data are summarized on an annual and a monthly basis in Figure 7.8 and in Appendix II. Data capture at this site has been satisfactory. Observed PM_{10} levels have been very low, with no exceedances reported and few annual PM_{10} increments estimated. Little difference was noted between 1994 and 1995 levels. Mean and maximum concentrations were 14 and 34 $\mu g / m^3$, respectively, for both years. On a monthly basis, the highest mean PM_{10} concentrations were observed in January (17 $\mu g / m^3$) and September (18 $\mu g / m^3$) and the lowest levels in December (10 $\mu g / m^3$).

7.4 SOUTHERN INTERIOR REGION

The Southern Interior Region (excluding the Okanagan sub-region) is serviced by manual PM_{10} samplers in Kamloops and Merritt. An additional continuous sampler is located in Kamloops. PM_{10} levels in both communities are discussed.

7.4.1 Kamloops

PM_{10} monitoring in Kamloops and its environs began in January / February 1990 at a total of four sites: the Airport, BCTel Valleyview, the Federal Building, and Brocklehurst. A fifth sampler at Westsyde began operating in May 1990. A continuous sampler was added to the Brocklehurst site in January 1994. At present, only the manual sampler at the Federal Building and the continuous sampler at Brocklehurst are still operating. Data from the Brocklehurst site are summarized on an annual and monthly basis in Figure 7.9 and in Appendix II. Unless indicated otherwise, data prior to 1995 are from the manual sampler, and recent data are from the continuous sampler.

Data capture at the Brocklehurst site has been satisfactory. Mean PM_{10} concentrations have fluctuated from year-to-year. However, it is noted that mean concentrations from 1994-1995 (17-19 $\mu g / m^3$) are substantially lower than 1990-1991 levels (26-29 $\mu g / m^3$). During this period, exceedance frequencies dropped from 8-11% to

approximately 2%. The number of PM_{10} increments, an indicator of increased risk of health effects due to PM_{10}, decreased from greater than 300 to less than 75.

On a monthly basis, the highest mean PM_{10} concentrations were observed in February-March (26-31 $\mu g / m^3$) and the lowest levels in April-August (15-18 $\mu g / m^3$). The highest concentration observed at this site was 221 $\mu g / m^3$ in February 1990.[1] Exceedances of the air quality objective have occurred during October-December, February-May and July.

7.4.2 Merritt

The manual sampler in Merritt began operating in January 1990. Data are summarized on an annual and monthly basis in Figure 7.10 and in Appendix II.

Data capture at this site has ranged from marginal to satisfactory. Based on the available data, PM_{10} levels in Merritt rank among the worst in the province. Mean concentrations in excess of 40 $\mu g / m^3$, exceedance frequencies in excess of 20%, and annual PM_{10} increments in excess of 500 have been calculated for at least three of the past six years . However, air quality in recent years is much improved over earlier levels. For instance, mean concentrations have decreased from 42-43 $\mu g / m^3$ in 1990-1991 to 32-36 $\mu g / m^3$ in 1994-1995. The number of annual PM_{10} increments have similarly dropped, from near 750 to less than 600. Nevertheless, the more recent PM_{10} measurements are still high relative to many other areas of the province, as reflected by an exceedance frequency of 20% in 1995.

In terms of monthly variations, mean PM_{10} levels were highest in February-March (48-62 $\mu g / m^3$) and in June-August (39-41 $\mu g / m^3$). The latter observation is unusual, as most other sites in the province experience lower PM_{10} levels during the summer. Instead, the lowest mean monthly concentrations were observed in September-November and January (29-33 $\mu g / m^3$). The highest PM_{10} concentration recorded at this site was 167 $\mu g / m^3$ in December 1994. Exceedances of the air quality objective were observed in each month of the year.

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[1] A dust storm associated with extremely high PM_{10} concentrations was not captured in this analysis. On March 4, 1995, hourly concentrations exceeded 900 $\mu g / m^3$ and the daily mean exceeded 350 $\mu g / m^3$.

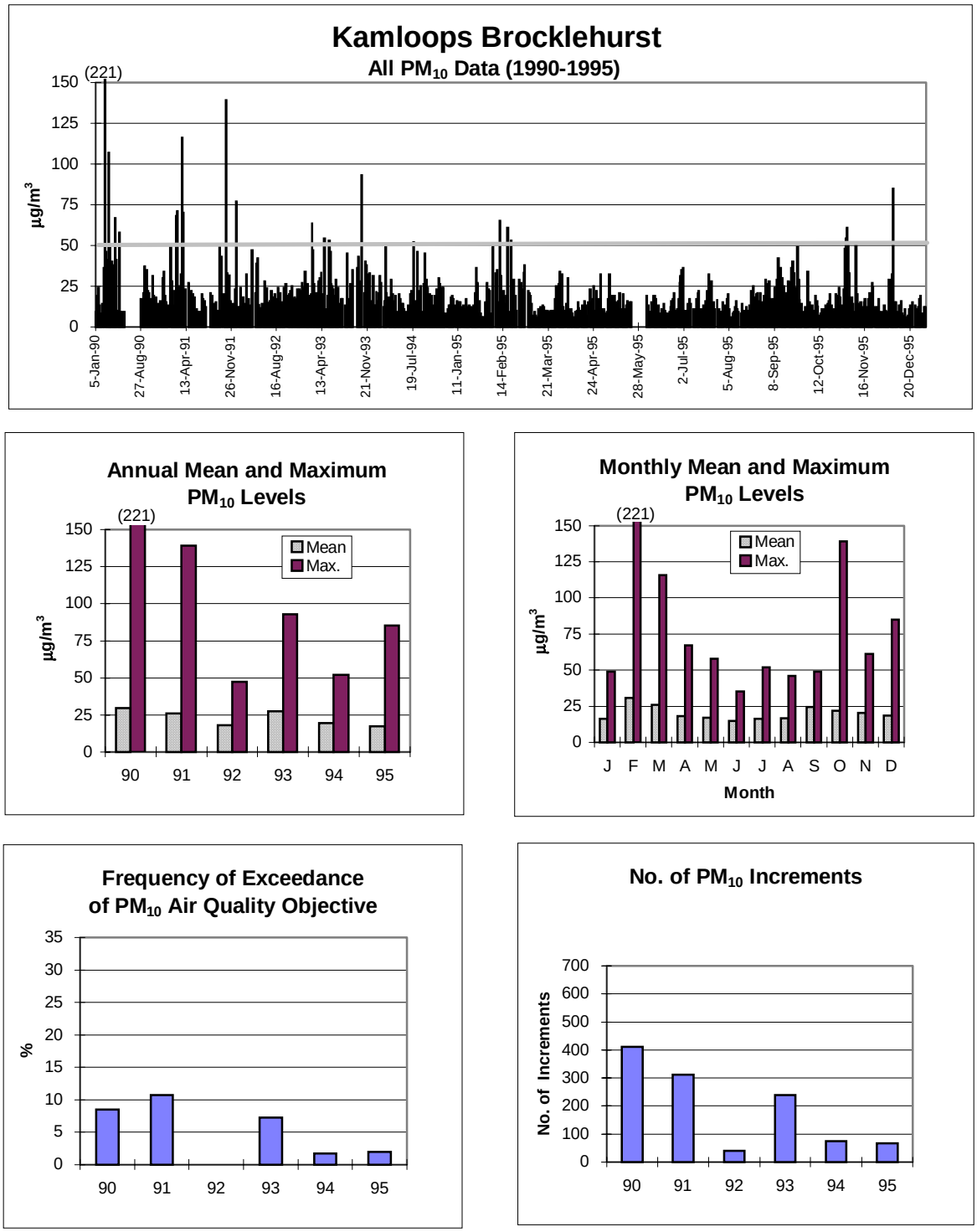
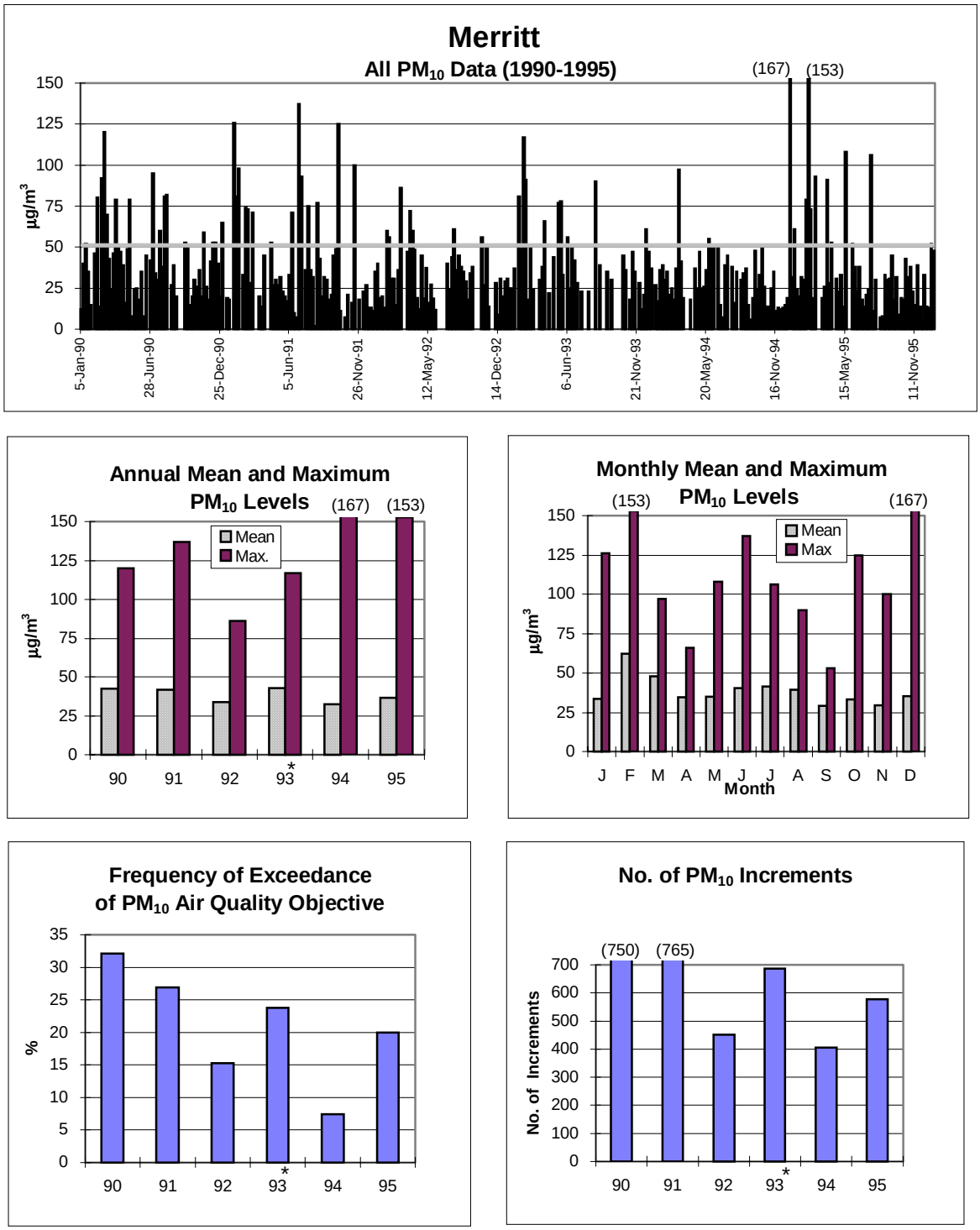


Figure 7.9 Summary of annual and monthly PM_{10} statistics, Kamloops.



* Less than 75% data capture.

Figure 7.10 Summary of annual and monthly PM_{10} statistics, Merritt .

7.5 KOOTENAY REGION

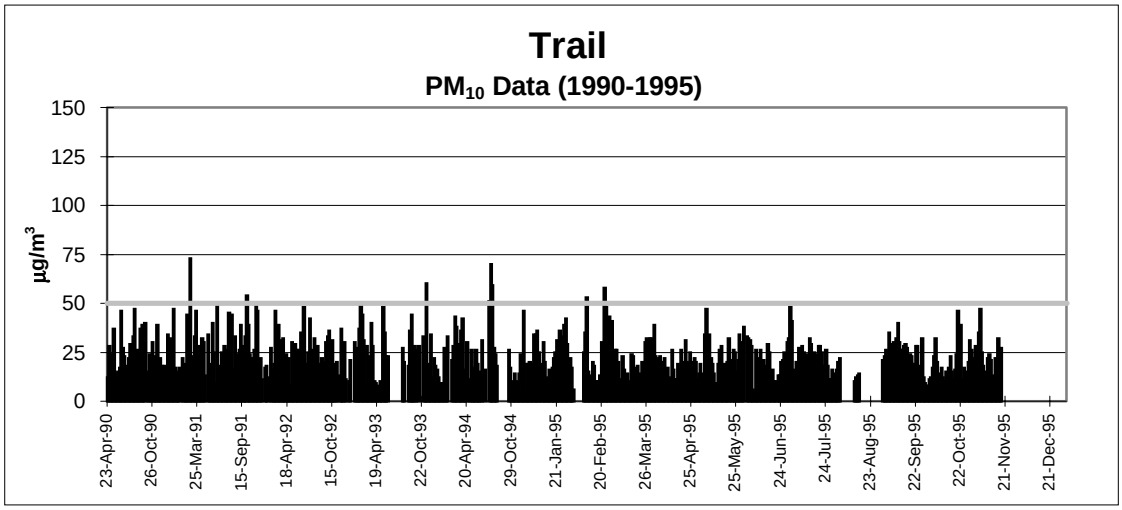
PM_{10} monitoring in the Kootenay Region dates back to April 1985, at the Cranbrook Amy Woodland site. Since this time, PM_{10} has been monitored at approximately 20 different sites. The current active network includes three continuous monitors (Trail, Creston and Cranbrook) and eleven manual samplers (Trail, Castlegar, Nelson, Nakusp, Slocan, Revelstoke, Golden, Skookumchuk, Invermere, Cranbrook and Creston). Data from the monitoring sites in Trail, Creston, Cranbrook and Golden are discussed below.

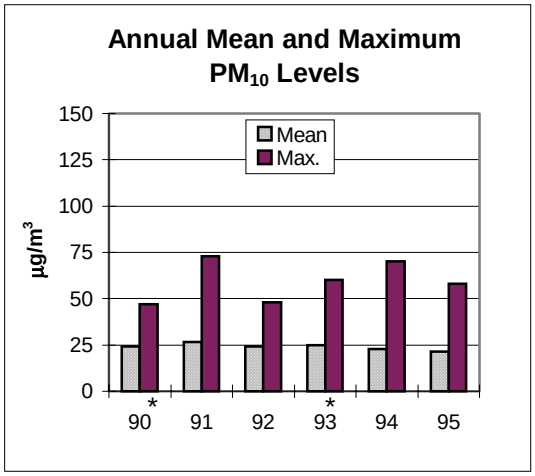
7.5.1 Trail

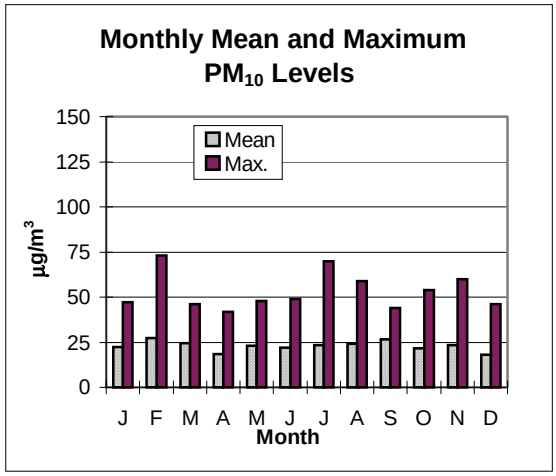
The Trail PM_{10} monitoring site is located in Butler Park, which lies 1.5 km to the east of the Cominco lead smelter. The manual sampler has been in operation since April 1990. A continuous sampler was installed at the same site in April 1994. Annual and monthly PM_{10} statistics are summarized in Figure 7.11 and in Appendix II. In the current treatment, data prior to 1995 are from the manual sampler, and recent data are from the continuous sampler.

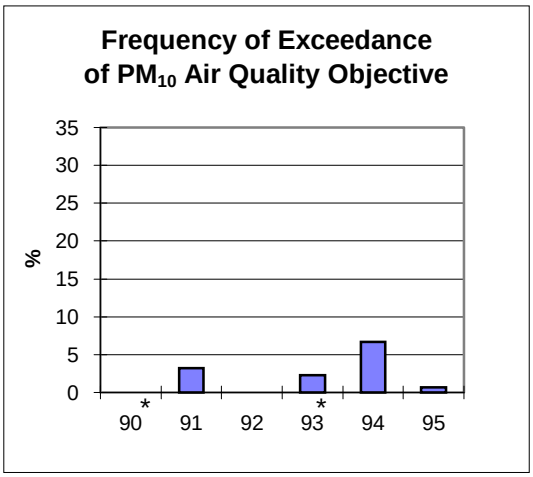
Over the past five years of operation, data capture has been satisfactory at this site. The lone exception was 1993, when data capture was marginal. Annual mean PM_{10} concentrations have varied from 21-27 $\mu g / m^3$, with the lowest concentrations and the lowest number of PM_{10} increments (79) of the five-year period occurring in 1995. During that year, the air quality objective for PM_{10} was exceeded less than 1% of the time.

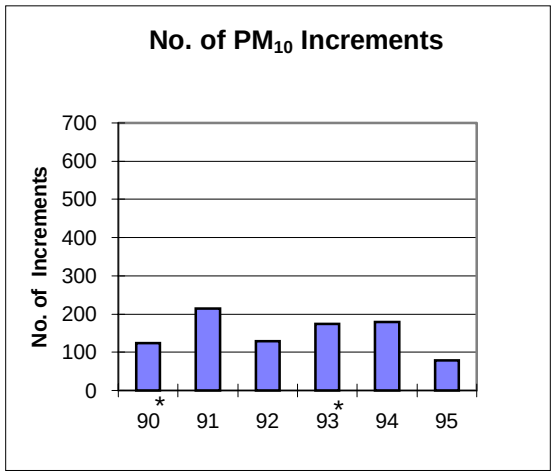
On a monthly basis, the highest mean PM_{10} concentrations were found in February (27 $\mu g / m^3$) and September (26 $\mu g / m^3$), and the lowest levels in December (18 $\mu g / m^3$). The highest PM_{10} concentration recorded at this site was 73 $\mu g / m^3$ in February 1991. Exceedances of the air quality objective were limited to the months of February, July-August, and October-November.











* Less than 75% data capture.

Figure 7.11 Summary of annual and monthly PM_{10} statistics, Trail .

7.5.2 Creston

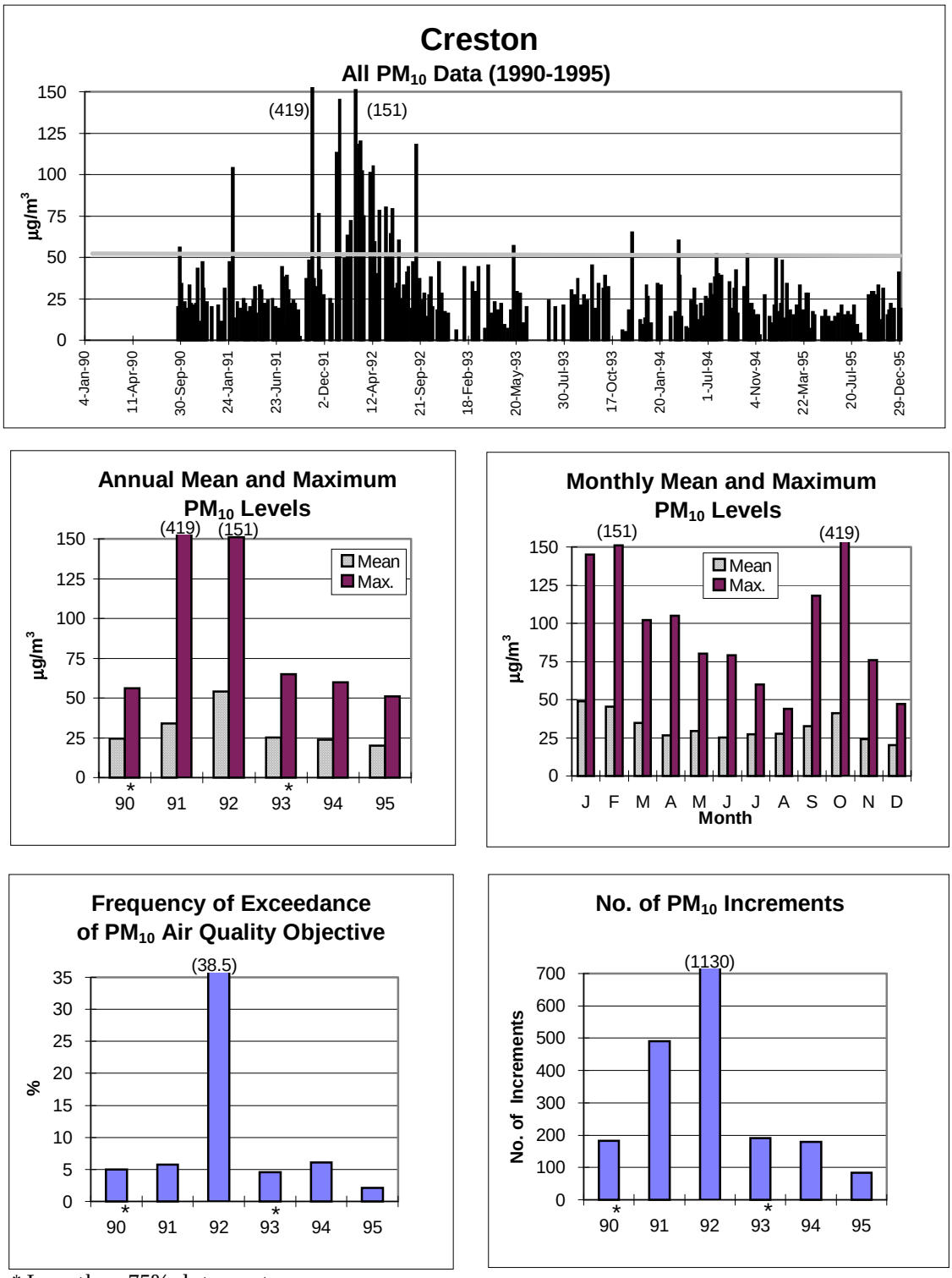
The manual sampler in Creston is located on the roof of the Creston Hospital. PM_{10} sampling began here in September 1990. A continuous sampler was installed at a second site in Creston in October 1994. The current treatment is restricted to data from the hospital site. Annual and monthly statistics are summarized in Figure 7.12 and in Appendix II.

In 1992, Creston experienced some of the highest PM_{10} levels in the entire province. The annual mean PM_{10} concentration was 54 $\mu g / m^3$ and the reported maximum concentration was 151 $\mu g / m^3$. The air quality objective was exceeded 38% of the time, and over 1000 PM_{10} increments were estimated. Since 1992, PM_{10} levels have been considerably improved. Mean concentrations have ranged from 20-25 $\mu g / m^3$, and exceedance frequencies have varied from 2-6%. The number of annual PM_{10} increments, which reflect an increased risk of health effects due to PM_{10}, are still high. However, they have not exceeded 200 since 1992. While not indicative of long-term trends, PM_{10} levels in 1995 were lower than any previous year.

In terms of monthly variations, the highest mean PM_{10} concentrations were found in January-February (45-49 $\mu g / m^3$) and October (41 $\mu g / m^3$), and the lowest levels were found in December (20 $\mu g / m^3$). The only months in which exceedances of the air quality objective were not observed were August and December. The highest concentration ever reported for this site and in the province, 419 $\mu g / m^3$, was in October, 1991.

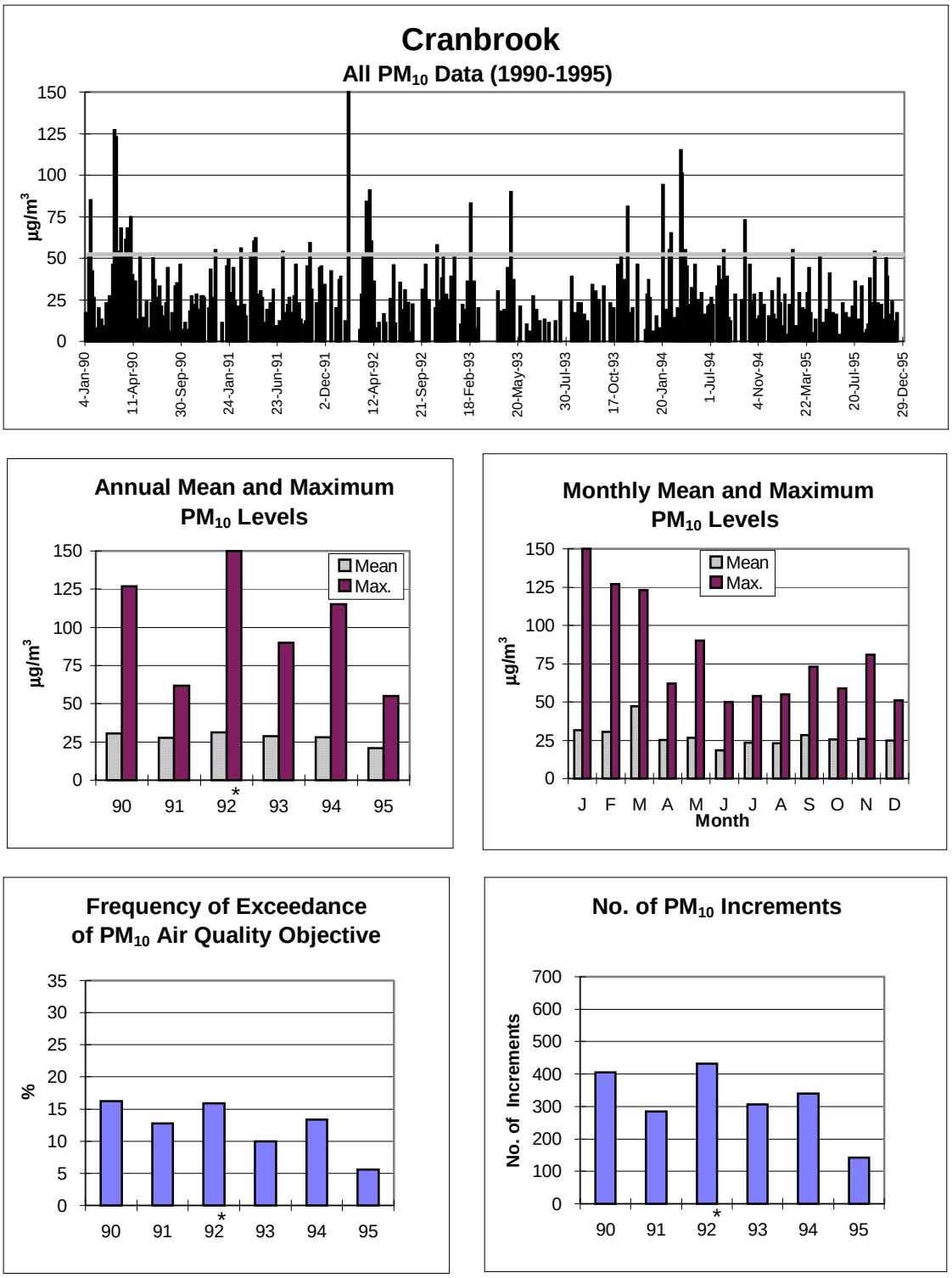
7.5.3 Cranbrook

Cranbrook is currently serviced by a manual sampler at the Cranbrook Swimming Pool and a continuous monitor located on 14th Avenue (PR3). Monitoring at the swimming pool began in March 1990, and the data are summarized on an annual and monthly basis in Figure 7.13, and in Appendix II.



* Less than 75% data capture.

Figure 7.12 Summary of annual and monthly PM_{10} statistics, Creston .



* Less than 75% data capture.

Figure 7.13 Summary of annual and monthly PM_{10} statistics, Cranbrook

Data capture at this site has been satisfactory for all but one of the past six years. PM_{10} levels have been high relative to most other areas of the province. Between 1990-1994, mean PM_{10} levels varied from 28-31 $\mu g / m^3$. The air quality objective was exceeded more than 10% of the time. The number of PM_{10} increments, reflecting an increased risk of health effects due to PM_{10}, averaged over 285. In 1995, however, exceedance frequencies dropped to about 6%. The mean concentration fell to 21 $\mu g / m^3$ and the number of PM_{10} increments declined by over 50%. It is unclear what particular factors led to this apparent improvement in air quality.

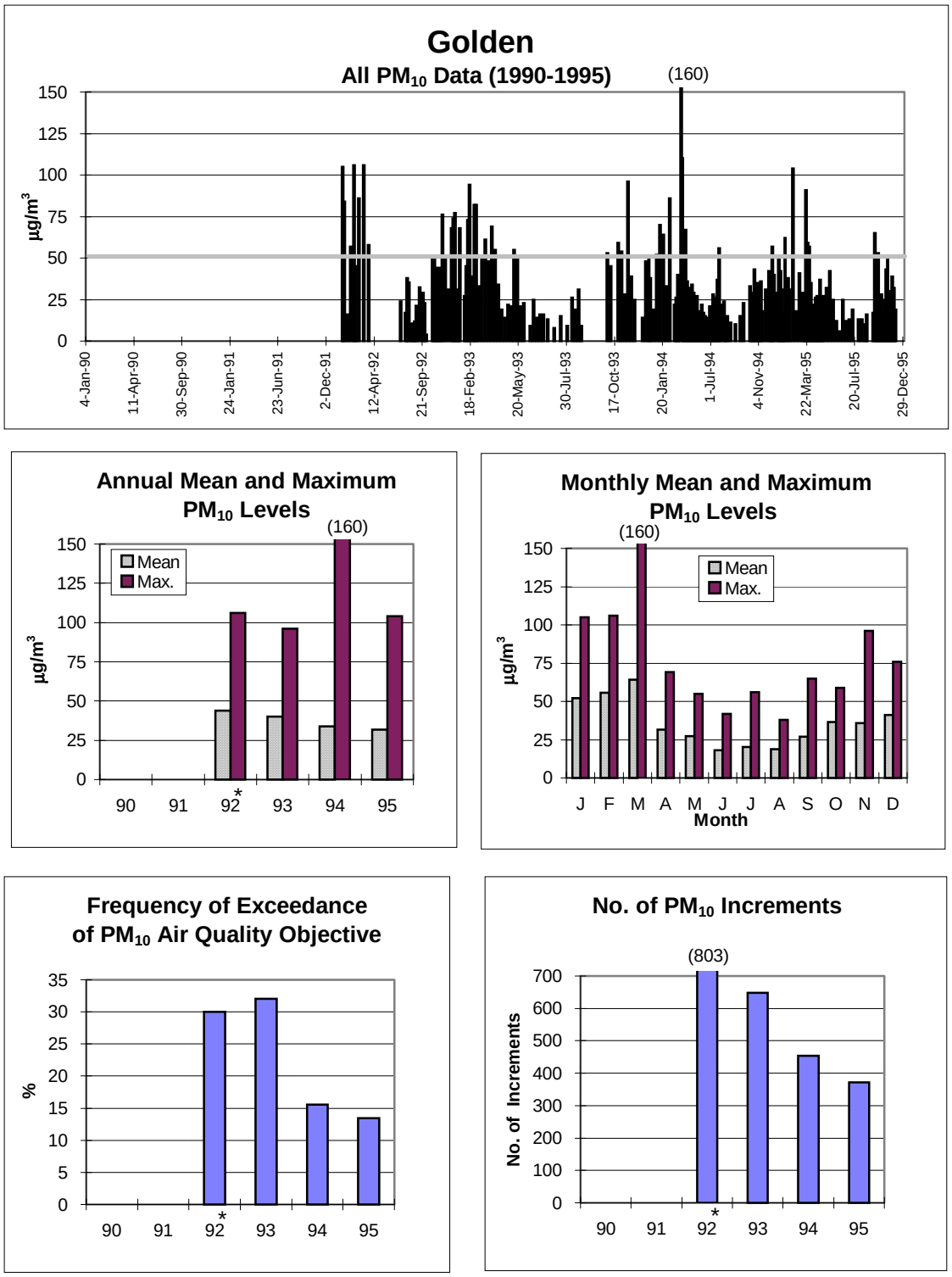
On a monthly basis, the highest mean PM_{10} concentrations were found in March (47 $\mu g / m^3$) and the lowest values in June (18 $\mu g / m^3$). Exceedances of the air quality objective were observed in every month of the year except June. The highest PM_{10} concentration observed at this site was 150 $\mu g / m^3$ in January 1992.

7.5.4 Golden

The manual sampler in Golden began operating in January 1992. Data are summarized on an annual and monthly basis in Figure 7.14 and in Appendix II.

Data capture at this site has been satisfactory over the past three years of full operation. During this period, mean PM_{10} concentrations decreased from 40 to 32 $\mu g / m^3$. Exceedance frequencies also fell from 32% to 13%. The number of annual PM_{10} increments, which reflect increased risks of health effects due to PM_{10}, dropped from 647 to 372. While these numbers suggest improving air quality in Golden, these levels are still very high relative to other areas of the province.

In terms of monthly variations, the highest mean PM_{10} concentrations were found in January-March (52-64 $\mu g / m^3$), and the lowest levels in June-August (18-20 $\mu g / m^3$). The air quality objective was exceeded in every month of the year except June and August. The highest recorded concentration (160 $\mu g / m^3$) occurred in March 1994.



* Less than 75% data capture.

Figure 7.14 Summary of annual and monthly PM_{10} statistics, Golden .

7.6 CARIBOO REGION

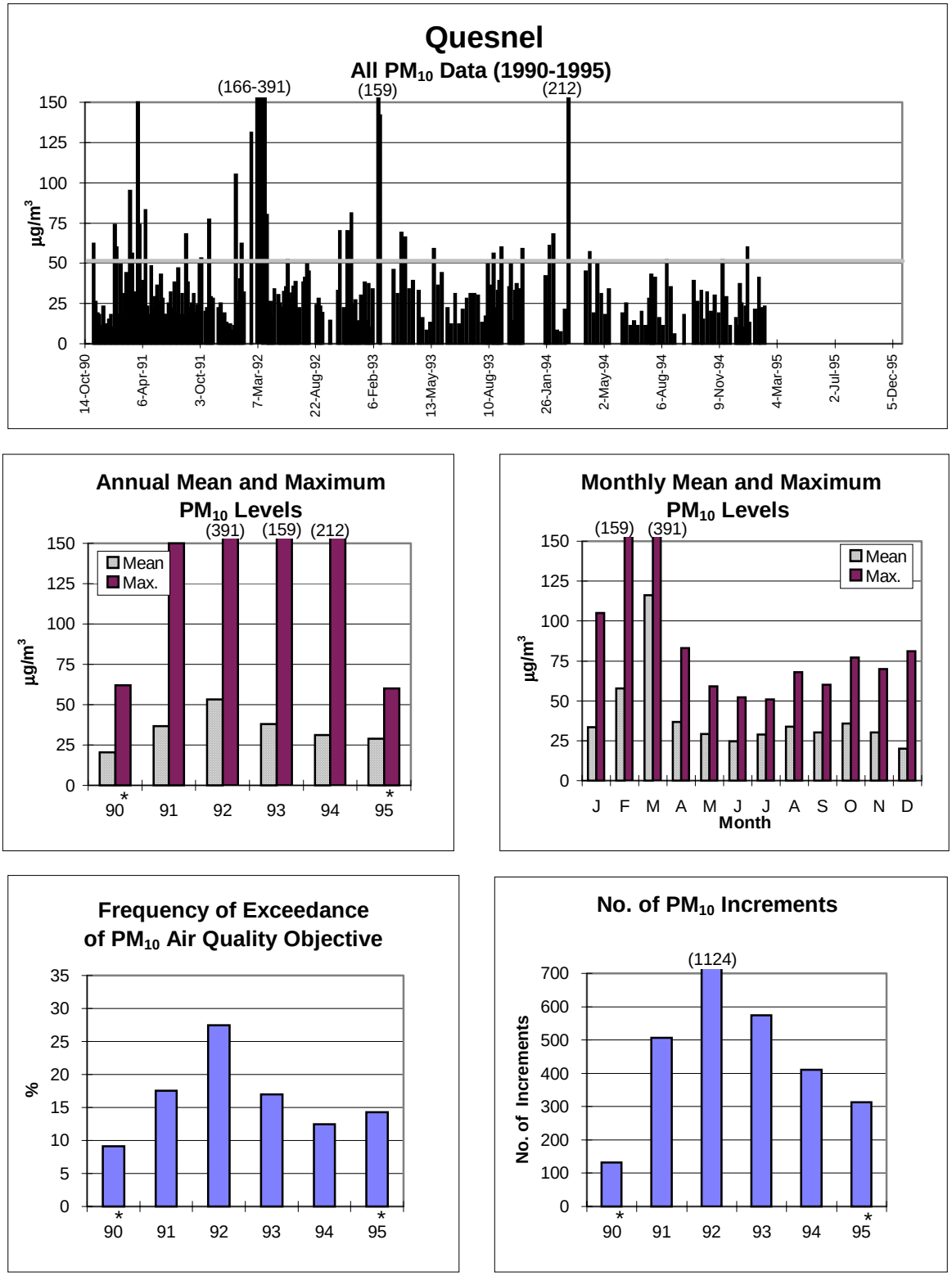
PM_{10} monitoring in the Cariboo Region began in May 1987. Measurements have been made at approximately 15 different locations. In the current provincial network, there are three active manual samplers in Williams Lake and one in 100 Mile House. A manual sampler in Quesnel was deactivated in early 1995. The network also includes four active continuous instruments in Williams Lake and Quesnel. In the following, data from manual samplers in Quesnel, Williams Lake (Firehall) and 100 Mile House are presented.

7.6.1 Quesnel

PM_{10} monitoring at the Quesnel Firehall began in November 1990, and continued until February 1995. Data from this site are summarized on an annual and monthly basis in Figure 7.15 and in Appendix II.

Data capture was satisfactory over the four full years of operation (1991-1994). PM_{10} levels at this site are high relative to other sites in the province. In 1994, the best year in terms of PM_{10} air quality, the mean concentration was 31 $\mu g / m^3$ and the air quality objective was exceeded 13% of the time. Over 400 PM_{10} increments, indicative of an increased risk in health effects due to PM_{10}, were estimated for the year. However, this is seen as an improvement over previous years when the number of PM_{10} increments exceeded 500 and exceedance frequencies approached 20%. PM_{10} levels in 1992 were particularly bad, with exceedance frequencies of 27% and the number of increments exceeding 1000.

On a monthly basis, mean PM_{10} concentrations were highest during March (116 $\mu g / m^3$), and lowest during December (20 $\mu g / m^3$). Exceedances were observed during all months of the year. Very high concentrations have been experienced at this site, as evidenced by maximum levels of 391 $\mu g / m^3$ in March 1992 and 212 $\mu g / m^3$ in March 1994.



* Less than 75% data capture.

Figure 7.15 Summary of annual and monthly PM_{10} statistics, Quesnel.

7.6.2 Williams Lake

PM_{10} monitoring in Williams Lake began in May 1987, at the Williams Lake Firehall. This site is located in a residential / business area of the city. Data from this site are summarized on an annual and a monthly basis in Figure 7.16 and in Appendix II.

Data capture has been satisfactory over the past five years of operation, with the exception of 1992, when it was marginal. Prior to 1994, PM_{10} levels measured at the Williams Lake site were among the highest in the province. Substantial improvement has been noted over the past two years. Between 1993 and 1995, annual mean concentrations decreased from 32 $\mu g / m^3$ to 22 $\mu g / m^3$. Exceedance frequencies similarly decreased, from 16% to 2%. The number of PM_{10} increments, which are indicative of an increased risk of health effects due to PM_{10}, decreased by over 50% to 153.

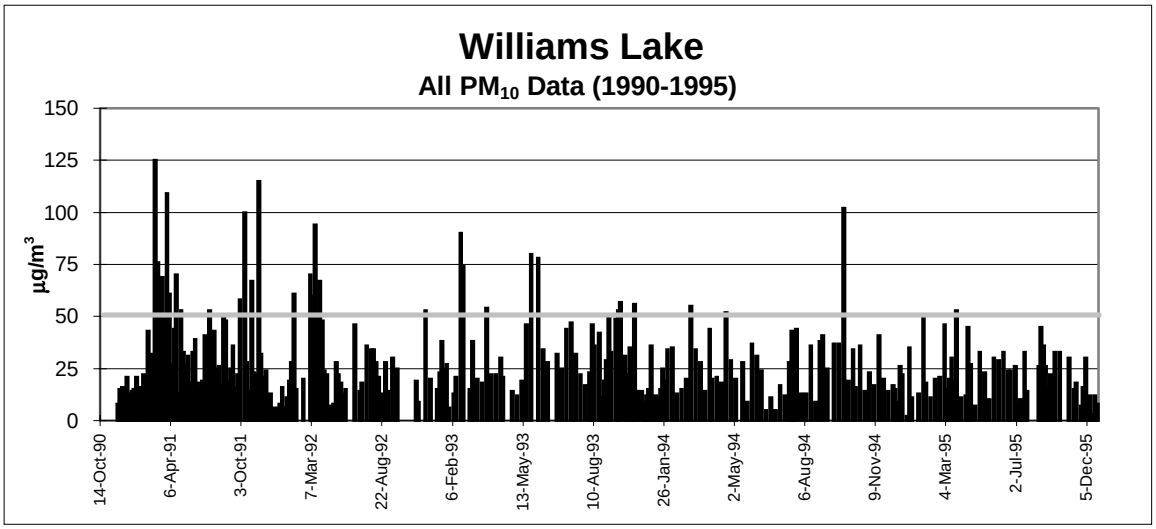
In terms of monthly variations, the highest mean concentrations were found in February-March (36-46 $\mu g / m^3$) and September-October (34-35 $\mu g / m^3$), and the lowest levels in December-January (15-18 $\mu g / m^3$). The highest concentration recorded at this site was 125 $\mu g / m^3$ in February 1991. The only months during which exceedances of the air quality objective were not recorded were January and June.

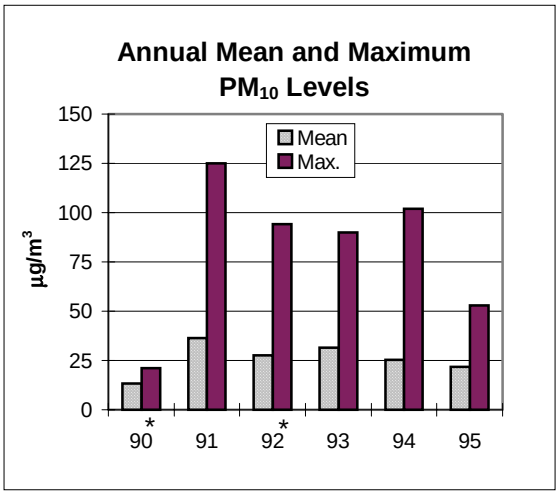
7.6.3 100 Mile House

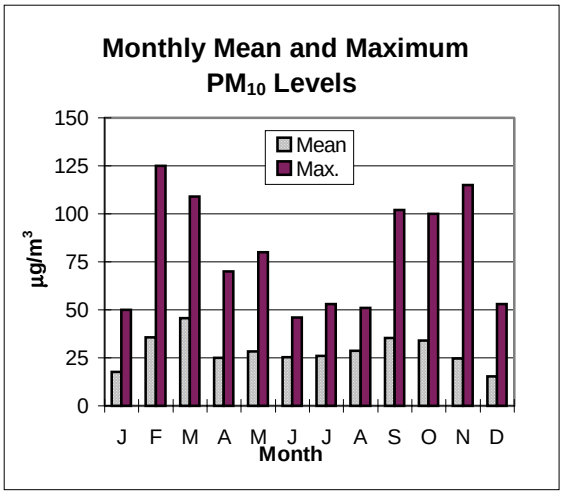
PM_{10} monitoring in 100 Mile House began in March 1993. The data are summarized on an annual and a monthly basis in Figure 7.17 and in Appendix II.

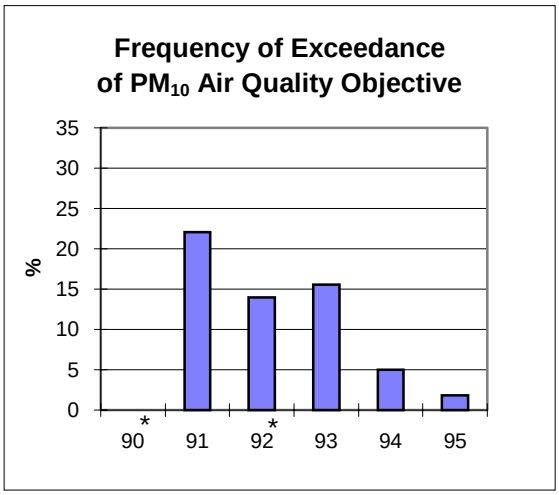
Data capture at this site has been satisfactory. Unlike other areas of the Cariboo Region, mean PM_{10} levels have actually increased over the last three years, from 18 $\mu g / m^3$ in 1993 to 27 $\mu g / m^3$ in 1995. Similarly, exceedance frequencies have increased from 4 to 13% . The number of PM_{10} increments, which reflect an increased risk of health effects due to PM_{10}, more than tripled from 91 to 282.

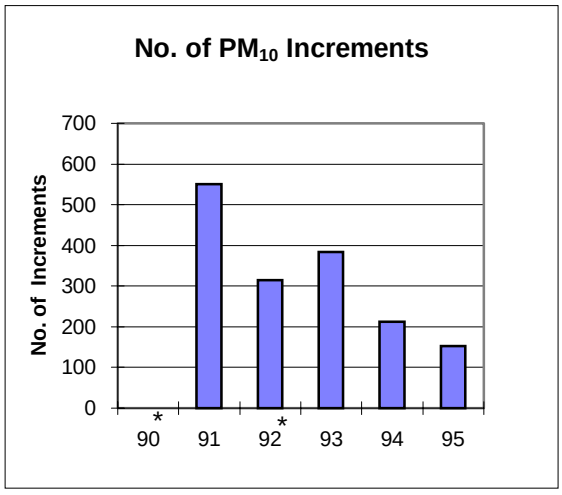
On a monthly basis, mean concentrations were highest in March (43 $\mu g / m^3$) and lowest in November-January (8-11 $\mu g / m^3$). The highest PM_{10} concentration recorded at this site was 105 $\mu g / m^3$ in March 1994. Exceedances of the air quality objective were observed during the months of February-March, May, July and September.











* Less than 75% data capture.

Figure 7.16 Summary of annual and monthly PM_{10} statistics, Williams Lake .

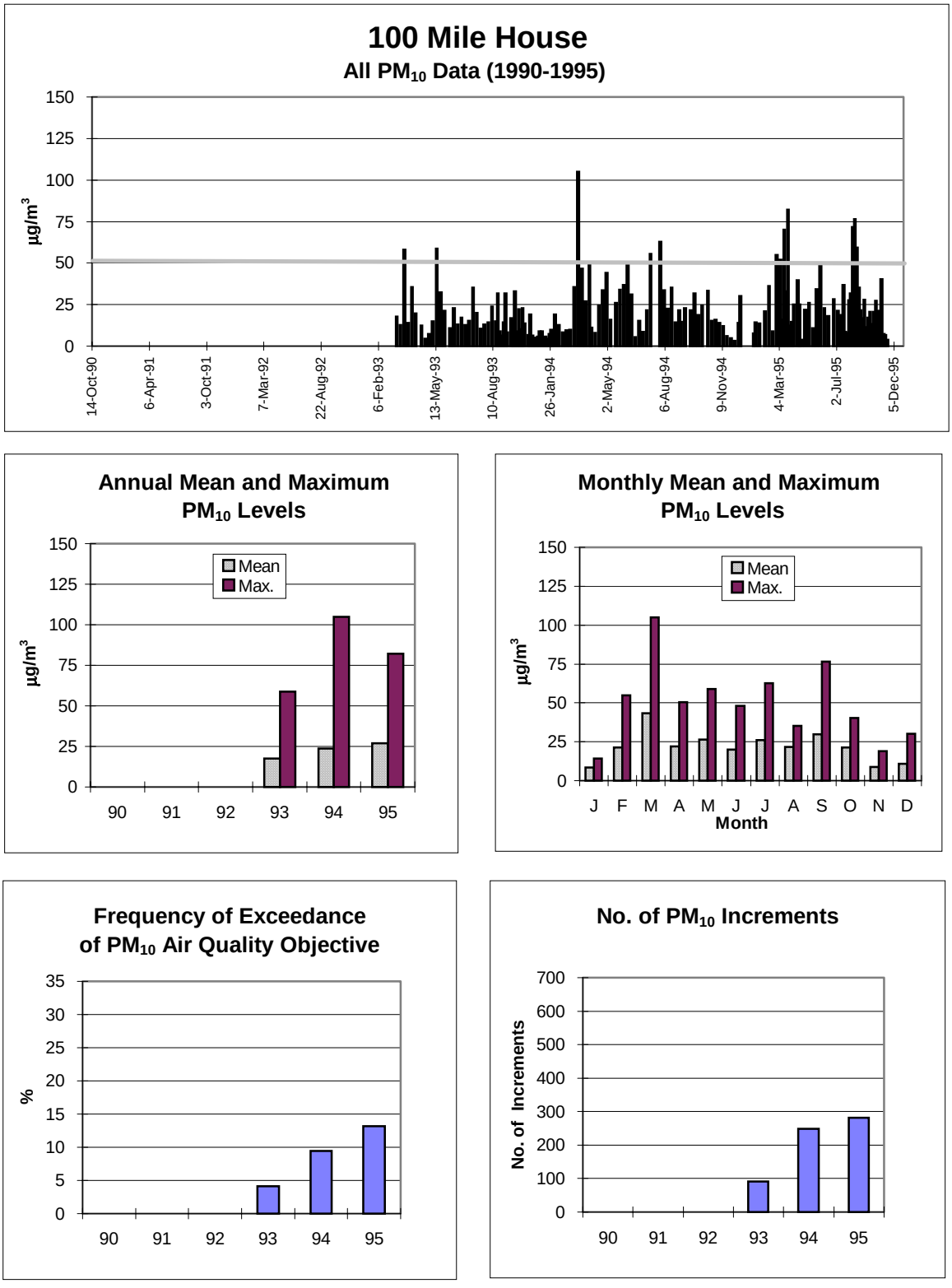


Figure 7.17 Summary of annual and monthly PM_{10} statistics, 100 Mile House.

7.7 SKEENA REGION

PM_{10} has been sampled at numerous locations in the Skeena Region. The current monitoring network includes manual samplers in Terrace, New Hazelton, Burns Lake and Kitimat, and continuous samplers in Houston, Smithers and Terrace. The continuous samplers provide the most current and complete data record; however, archiving difficulties limit the current analysis to the data from the manual samplers. Data from the manual sampling sites in Terrace and New Hazelton are presented in the following.

7.7.1 Terrace

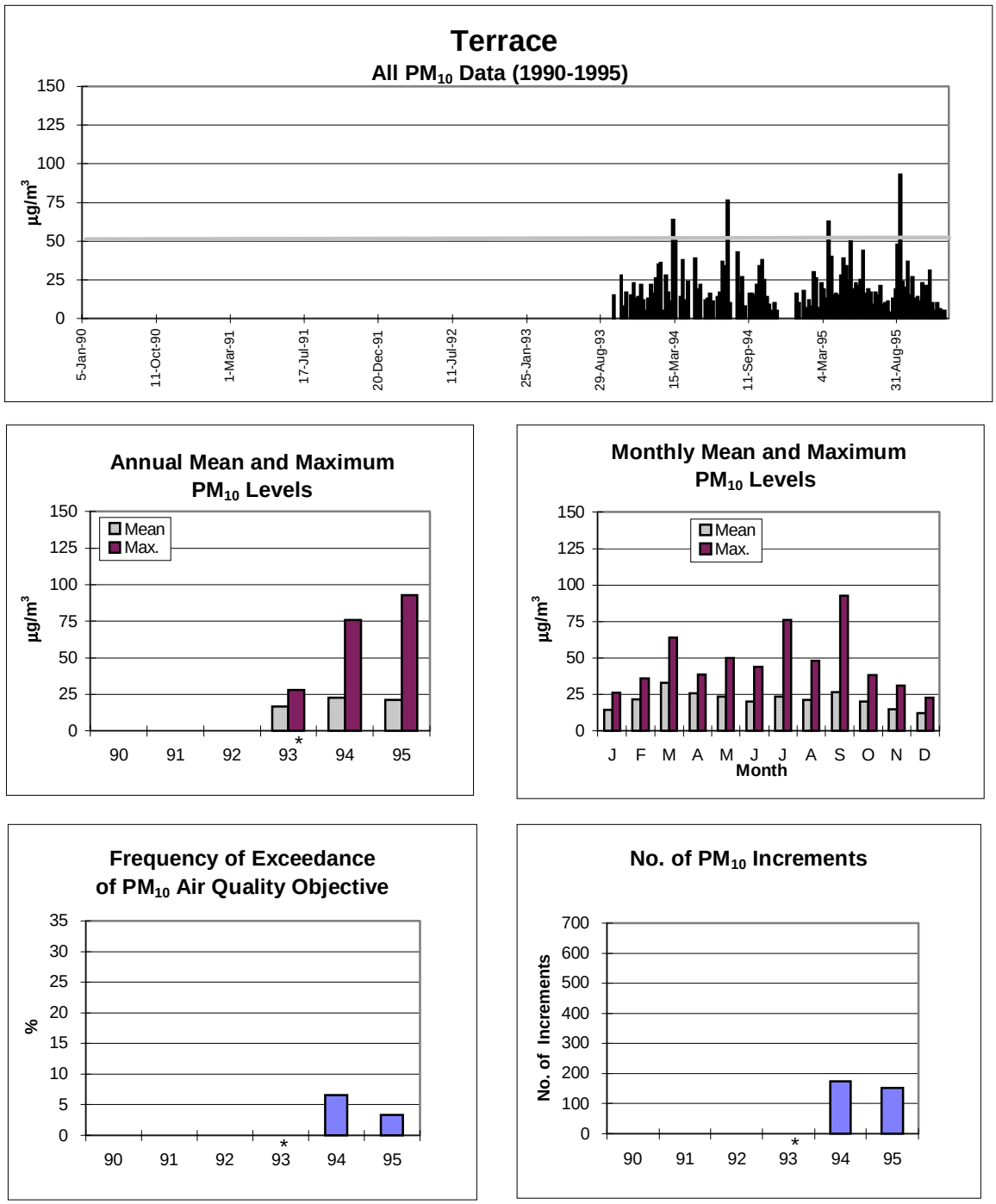
The manual sampler in Terrace is located at the firehall. It began operation in October 1993. Annual and monthly PM_{10} statistics from this site are summarized in Figure 7.18 and in Appendix II.

Data capture during the two complete years of operation is satisfactory. During this period, mean concentrations ranged from 21-23 $\mu g / m^3$. The air quality objective for PM_{10} was exceeded 3-6% of the time. The number of annual PM_{10} increments, indicative of an increased risk of health effects due to PM_{10}, varied from 152-175 during this time period. The highest PM_{10} concentration observed at this site was 93 $\mu g / m^3$ in September 1995. On average, PM_{10} levels were highest during the month of March (33 $\mu g / m^3$) and lowest between November -January (12-15 $\mu g / m^3$). Exceedances of the air quality objective were found in the months of March, July and September.

7.7.2 New Hazelton

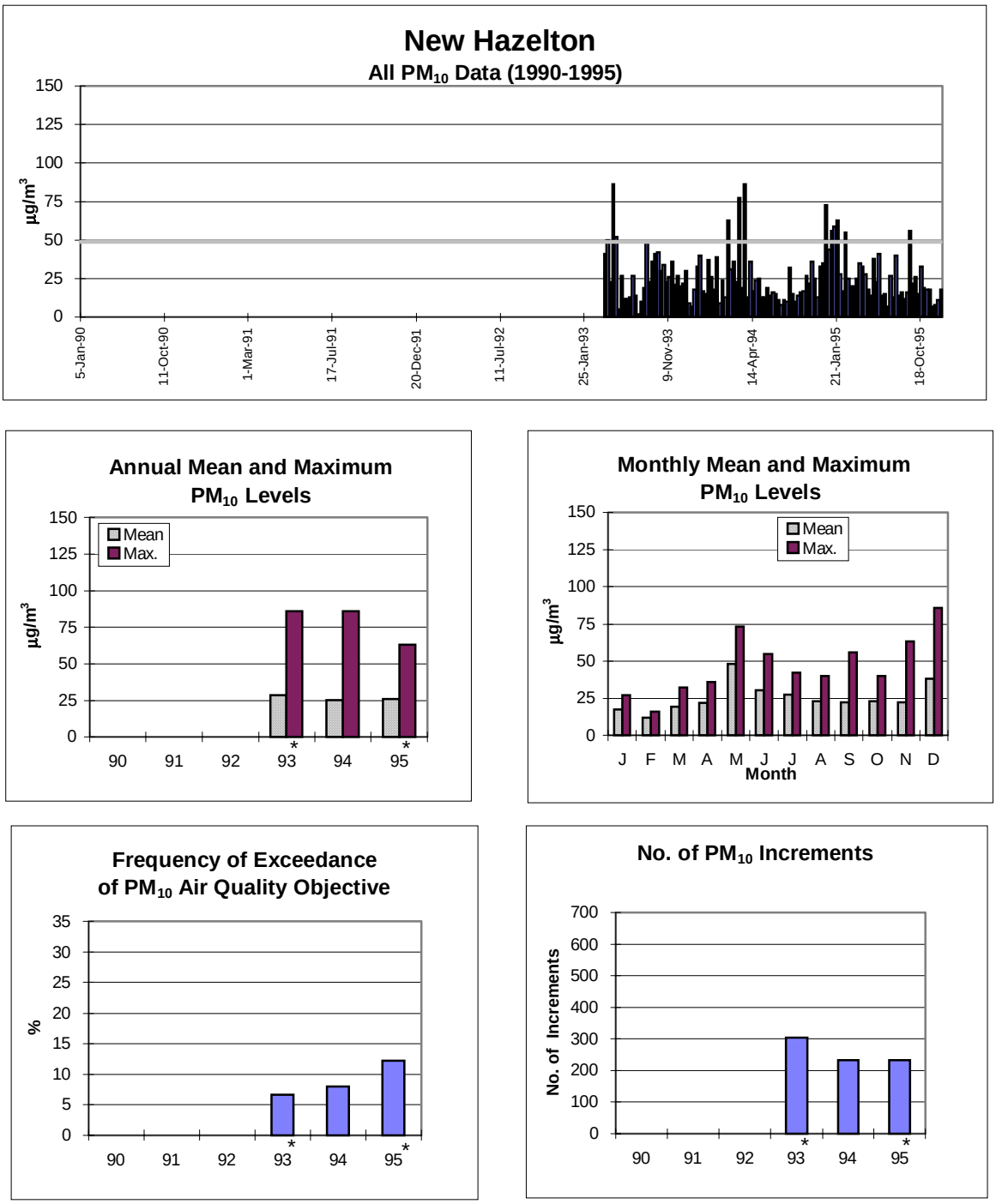
The manual sampler in New Hazelton began operating in March 1993. Annual and monthly statistics are summarized in Figure 7.19 and in Appendix II.

Data capture was acceptable in 1994 and marginal in 1995. During this time, mean PM_{10} concentrations ranged from 25-26 $\mu g / m^3$. The air quality objective for PM_{10}



* Less than 75% data capture.

Figure 7.18 Summary of annual and monthly PM_{10} statistics, Terrace .



* Less than 75% data capture.

Figure 7.19 Summary of annual and monthly PM_{10} statistics, New Hazelton.

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was exceeded 8-12% of the time. Over 200 PM_{10} increments, which are indicative of an increased risk of health effects due to PM_{10}, were estimated. Based on the limited dataset, mean PM_{10} concentrations were highest during the months of May and December, and lowest in February. Exceedances of the air quality objective were observed during the months of May-June, September, and November-December.

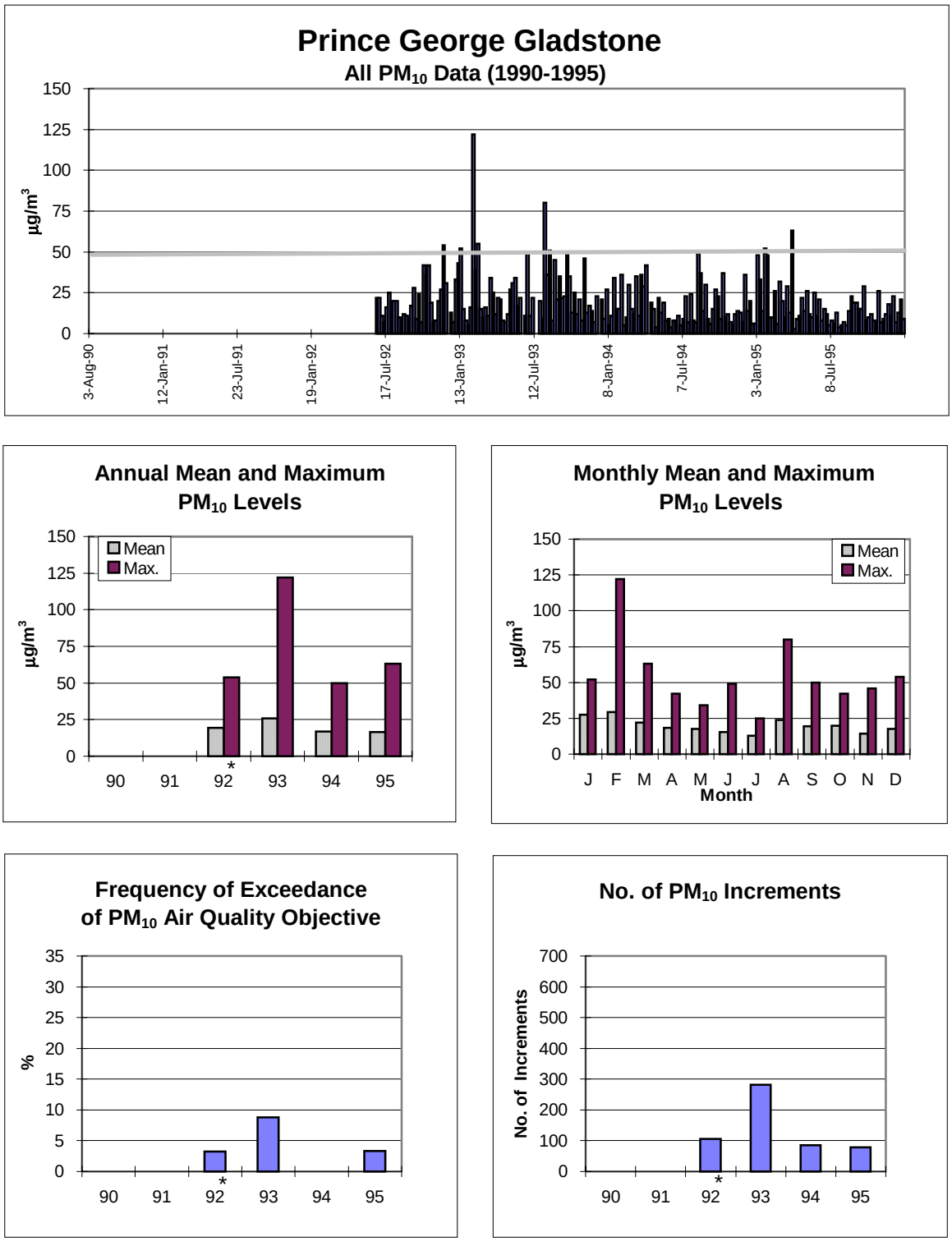
7.8 OMINECA-PEACE REGION

The City of Prince George is home to a number of large industrial facilities, including 3 pulp and paper mills, a refinery, as well as numerous sawmills and related activities. Reflecting the heavy concentration of industry within Prince George, PM_{10} has been measured at a total of seven different locations within the city since August 1990. The current monitoring network includes six manual samplers and two continuous instruments. Data from the Gladstone, Plaza 400 and BCRail sites are presented in the following. Limited monitoring has also been carried out in Chetwynd and Ft. St. James, but the data are not included in this report.

7.8.1 Gladstone School

Gladstone School is located in a residential area of Prince George. A manual sampler has been operating at this site since June 1992. A continuous sampler was added in December 1995. Data from the manual sampler are summarized on an annual and a monthly basis in Figure 7.20 and in Appendix II.

Data capture has been satisfactory for the three full years the sampler has been in operation. PM_{10} levels have changed little over the past two years at this site. Mean annual concentrations were 17 $\mu g / m^3$ both years. The number of PM_{10} increments, which reflect an increased risk of health effects due to PM_{10}, were 79-85. Exceedance frequencies were slightly higher in 1995 (3%) than in 1994, when no exceedances were reported. However, this is seen as an improvement over 1993 levels, when the air quality objective for PM_{10} was exceeded approximately 9% of the time, and a total of 282 PM_{10} increments were calculated.



* Less than 75% data capture.

Figure 7.20 Summary of annual and monthly PM_{10} statistics, Prince George Gladstone .

On a monthly basis, the highest mean PM_{10} concentrations were found in January-February (28-29 $\mu g / m^3$) and the lowest levels in June-July and November (13-15 $\mu g / m^3$). The highest concentration measured at this site (122 $\mu g / m^3$) was observed in February 1993. Exceedances of the air quality objective were found in the months of December-March, and in August.

7.8.2 Plaza 400

Plaza 400 is located in downtown Prince George. A manual sampler began operating at this site in August 1990. A continuous sampler was added in March 1992. Data from the manual sampler are summarized on an annual and a monthly basis in Figure 7.21 and in Appendix II.

Similar to the Gladstone site, PM_{10} levels measured at Plaza 400 have remained fairly stable over the past few years. However, concentrations are substantially higher at the Plaza 400 site, with mean concentrations ranging from 24 to 30 $\mu g / m^3$ between 1991-1995.[2] During this period, the air quality objective was exceeded 10-17% of the time. The number of PM_{10} increments, which reflect an increased risk of health effects due to PM_{10}, varied from 225 to 384.

On a monthly basis, mean PM_{10} concentrations were highest in February-March (34-51 $\mu g / m^3$) and lowest in July (21 $\mu g / m^3$). The highest concentration observed at this site was 217 $\mu g / m^3$ in March 1991. May and July were the only months in which no exceedances of the air quality objective were observed.

7.8.3 BCRail

The BCRail site is representative of an industrial setting. It was originally located to monitor emissions from nearby sawmill burners. A manual sampler has been operating at this site since May 1990, but archived data are available from July 1992. Annual and monthly statistics are summarized in Figure 7.22 and in Appendix II.

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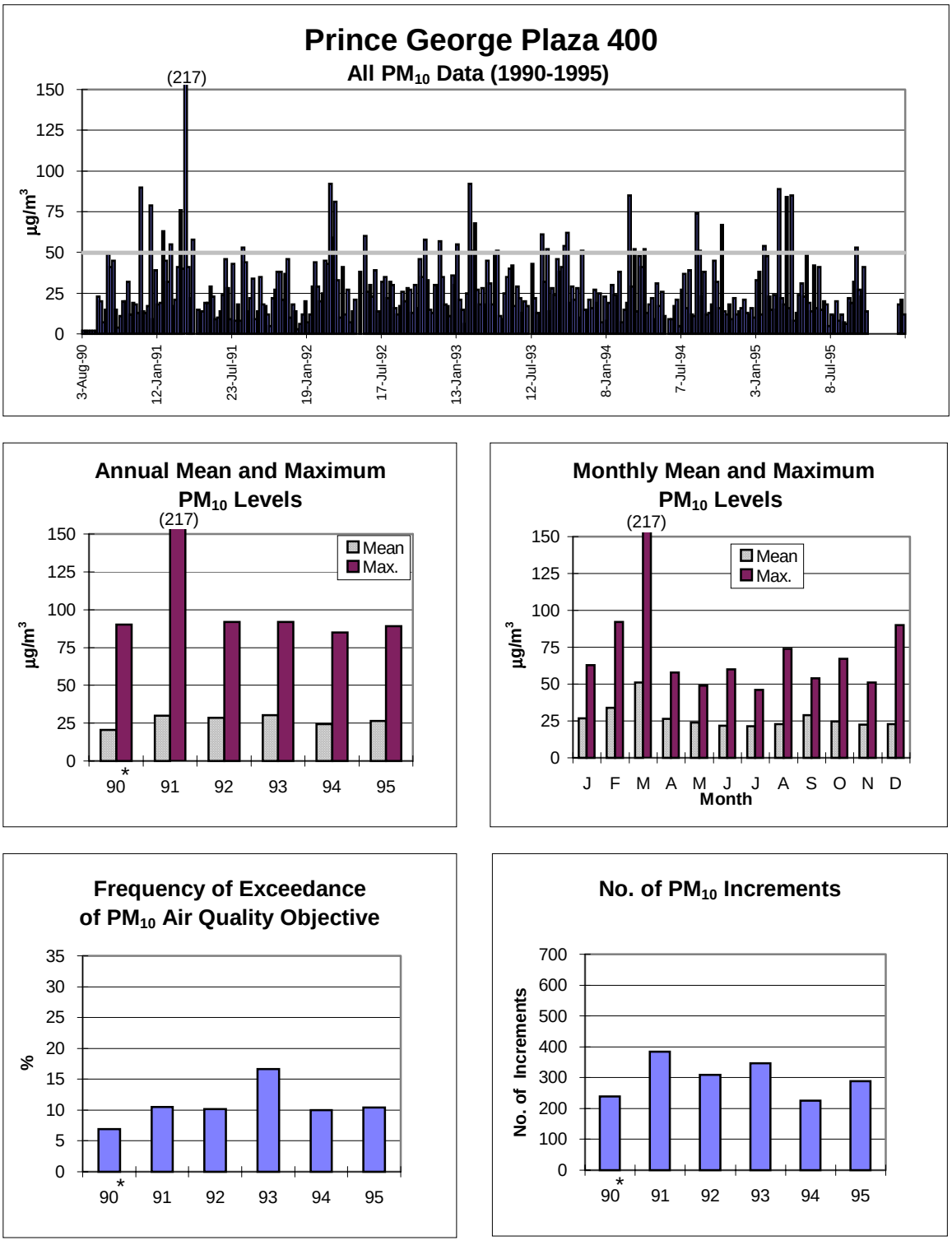
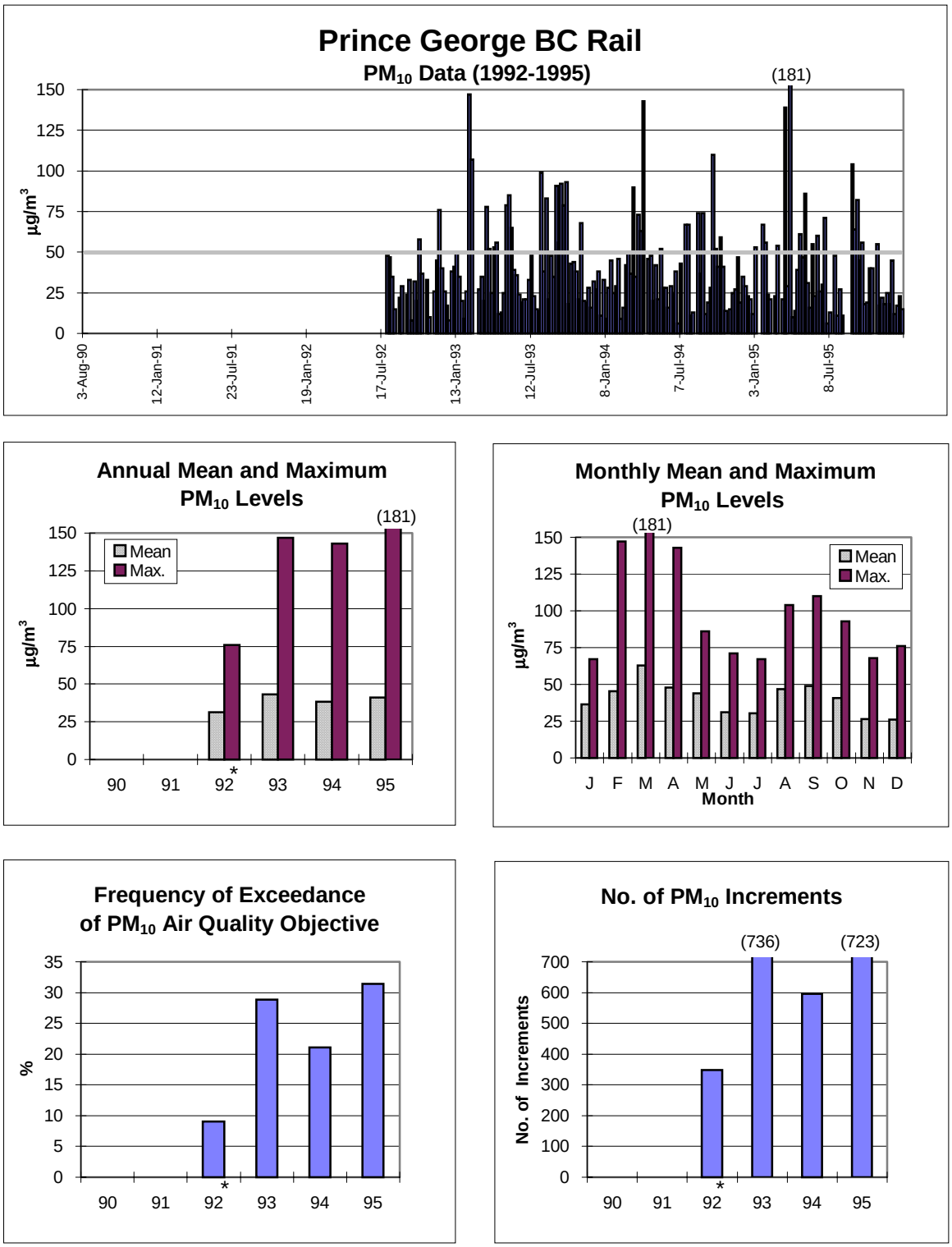
[2] Data from the continuous sampler indicate slightly lower levels, with mean concentrations of 22-24 $\mu g / m^3$, exceedance frequencies of 5-9% and increments of about 170-230 between 1994-95



* Less than 75% data capture.

Figure 7.21 Summary of annual and monthly PM_{10} statistics, Prince George Plaza 400 .



* Less than 75% data capture.

Figure 7.22 Summary of annual and monthly PM_{10} statistics, Prince George BCRail.

PM_{10} levels at the BCRail site are among the highest in Prince George and in the province, with no indication of a downward trend with time. In 1995, the air quality objective for PM_{10} was exceeded almost one-third of the time, more frequently than any previous year. The mean concentration was 41 $\mu g / m^3$. A total of 723 annual PM_{10} increments, reflecting an increased risk of health effects due to PM_{10}, were calculated.

On a monthly basis, mean PM_{10} concentrations were highest during February-April (45-63 $\mu g / m^3$) and August-September (47-49 $\mu g / m^3$) and lowest during November-December (26 $\mu g / m^3$). Exceedances were observed in every month of the year. The highest concentration recorded at this site was 181 $\mu g / m^3$ in March 1995.

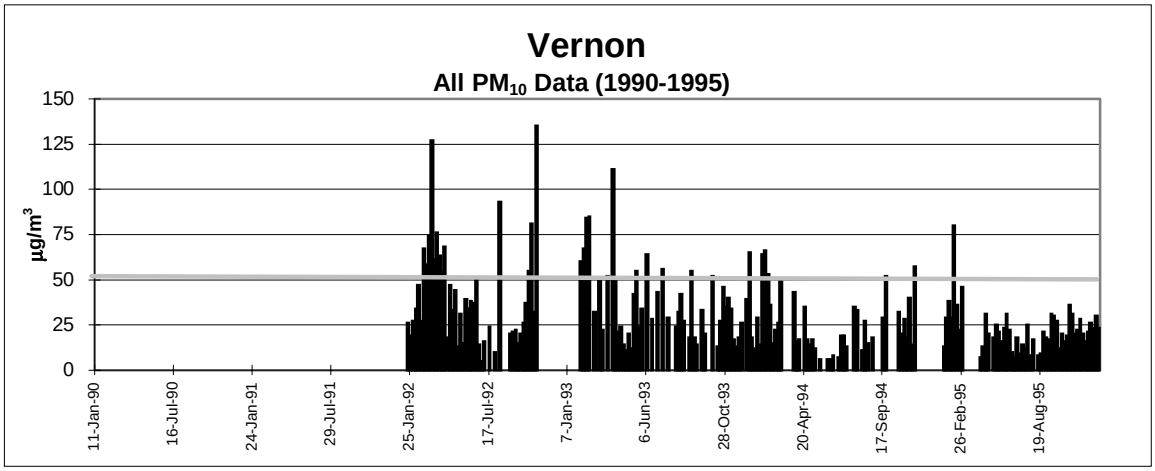
7.9 SOUTHERN INTERIOR SUB-REGION (OKANAGAN)

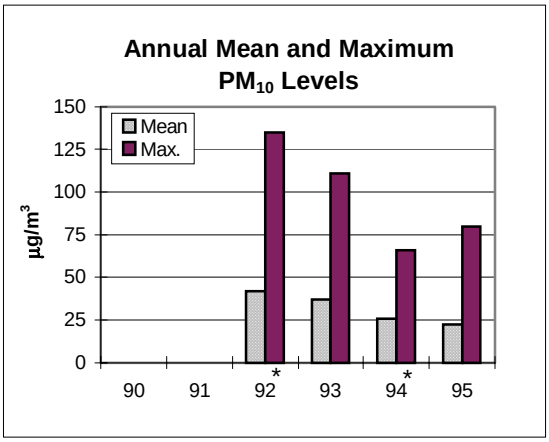
PM_{10} monitoring in the Okanagan began in May 1990. Five manual samplers are deployed in Vernon, Penticton, Lumby, Grand Forks and Kelowna. A continuous monitor is also located in Kelowna. Data from the Vernon and Kelowna sites are discussed below.

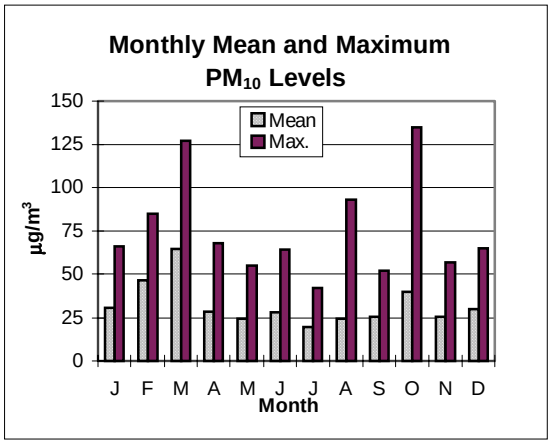
7.9.1 Vernon

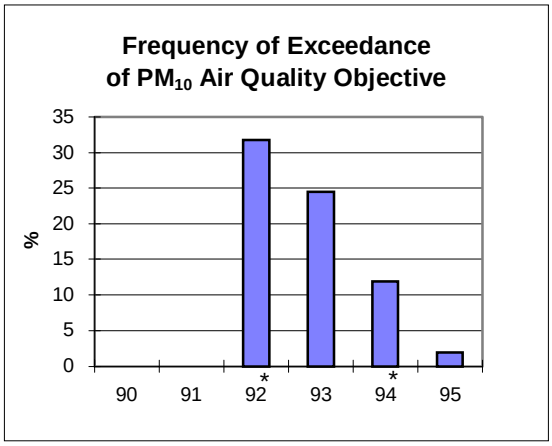
A manual sampler has been operating intermittently in downtown Vernon since October 1989, and more regularly since 1992. Data from this site are summarized on an annual and a monthly basis in Figure 7.23 and in Appendix II.

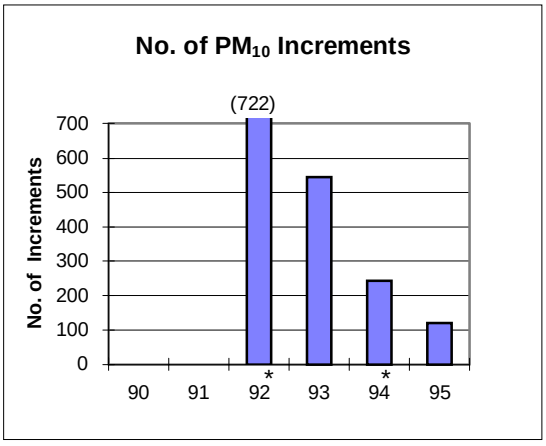
Data capture at this site has not been very good, particularly in the years prior to 1995, and so caution must be exercised in evaluating these numbers. The available data indicate that PM_{10} levels have shown a marked improvement over the past four years. In 1992, the air quality in Vernon due to PM_{10} was among the worst in the province. Mean PM_{10} levels were 42 $\mu g / m^3$, and the air quality objective was exceeded about 32% of the time. The number of PM_{10} increments, reflecting an increased risk in health effects due to PM_{10}, totalled over 700 for the entire year. By 1995, however, mean PM_{10} levels had fallen











* Less than 75% data capture.

Figure 7.23 Summary of annual and monthly PM_{10} statistics, Vernon .

to 22 $\mu g / m^3$ and the air quality objective was exceeded only 2% of the time. The number of PM_{10} increments had decreased to 119.

On a monthly basis, the highest mean concentrations were found to occur in February-March (46-65 $\mu g / m^3$) and October (40 $\mu g / m^3$). The lowest concentrations were found in July (20 $\mu g / m^3$), the only month during which exceedances of the air quality objective were not observed. The highest concentration measured at this site between 1990-1995 was 135 $\mu g / m^3$ in October 1992.

7.9.2 Kelowna

Both a manual and a continuous sampler are located at the KLO Road campus of Okanagan University College in Kelowna. The manual sampler began operating in September 1989, and the continuous sampler in January 1994. Data from the manual sampler are summarized on an annual and monthly basis in Figure 7.24 and in Appendix II.

Data capture has been satisfactory for all years except 1992. Relative to other locations in the Okanagan such as Vernon, PM_{10} levels at the Kelowna site have been fairly low. Although not necessarily indicative of long-term trends, the lowest mean concentrations have been observed over the past two years. In 1994 and 1995, mean concentrations were 21 and 19 $\mu g / m^3$, respectively.[3] The air quality objective was exceeded about 2% of the time. The number of PM_{10} increments, which are indicative of an increased risk in health effects due to PM_{10} levels, were 133 and 79, respectively.

On a monthly basis, the highest mean concentrations were found in February-March (36-39 $\mu g / m^3$) and the lowest concentrations in June (12 $\mu g / m^3$). The highest daily concentration measured at this site was 130 $\mu g / m^3$ in October 1991. Exceedances of the air quality objective were observed during the months of December-March, May, July and October.

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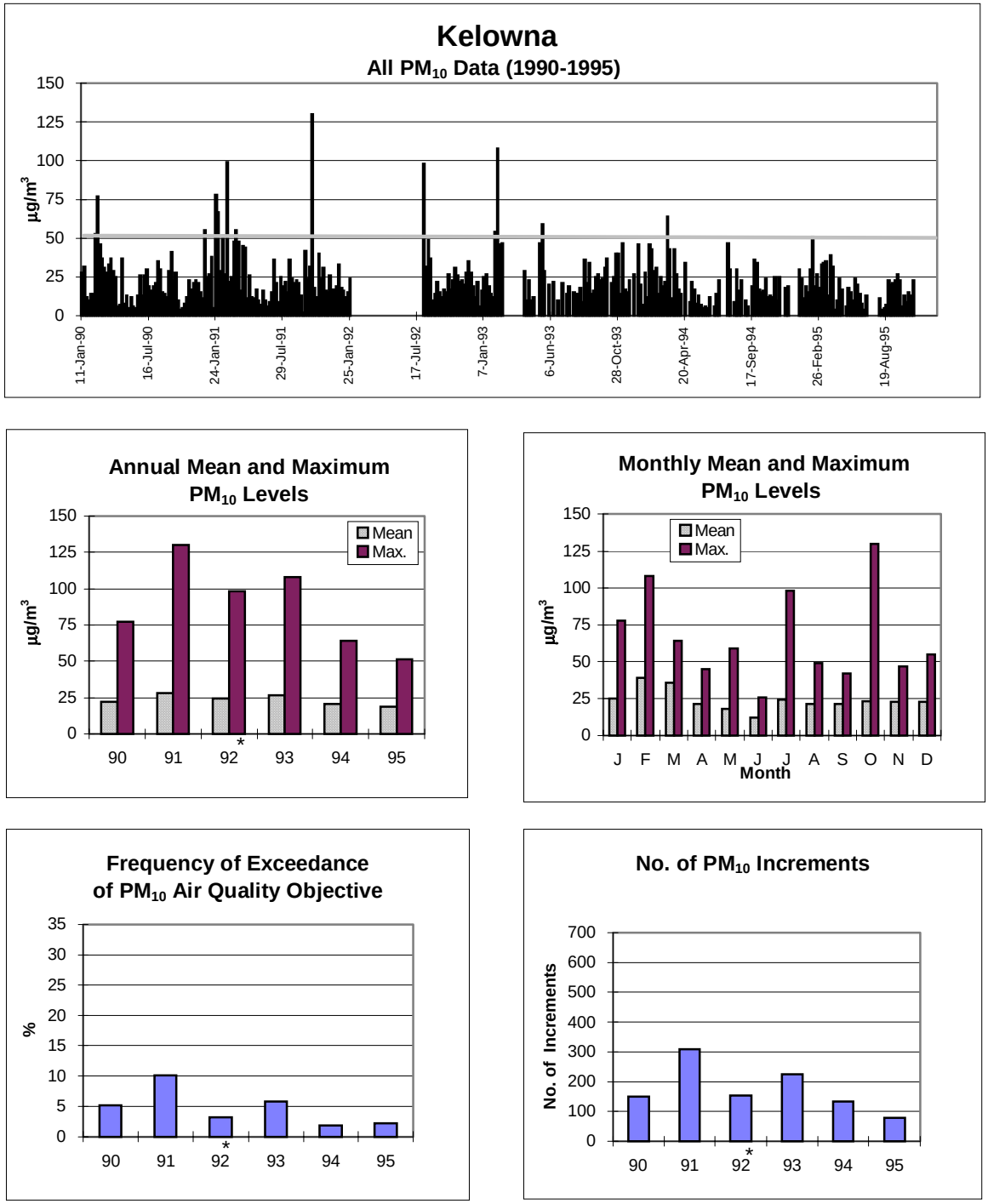
[3] Measurements from the continuous monitor indicate slightly lower PM_{10} levels. In 1995, the mean concentration was 17 $\mu g / m^3$, the exceedance frequency was less than 2% and approximately 60 increments were calculated.



* Less than 75% data capture.

Figure 7.24 Summary of annual and monthly PM_{10} statistics, Kelowna.

8. SUMMARY

Fine particulate matter, PM_{10}, has been measured at close to 100 sites throughout the province over the past 10 years. Although parts of the data have been reviewed on a regional basis, this report marks the first opportunity to evaluate province-wide levels.

The current assessment was limited to data from 1990-1995. An attempt was made to characterize PM_{10} levels within each of the eight regions and sub-regions of BC Environment, and within the Greater Vancouver Regional District (GVRD). Given the large number of monitoring sites and the intermittent data collection at some locations, the assessment was primarily limited to those sites exhibiting good data availability. In the situation where multiple stations were located in the same community, the stations considered the most representative of the area were selected. Hence, sites with the worst or the best air quality in the province may not have been considered here.

The following observations were drawn from these analyses:

1. Annual mean PM_{10} concentrations ranged from less than 15 to greater than 50 $\mu g / m^3$.
2. At monitoring sites in southwestern BC (Vancouver Island, Lower Mainland and GVRD), annual mean concentrations were typically less than 20 $\mu g / m^3$. This compares with sites in the rest of the province, which were mostly in the range of 20-30 $\mu g / m^3$.
3. On average, the highest concentrations were recorded in the interior of the province; particularly in Prince George (BCRail and Plaza 400), Quesnel, Merritt and Golden. Over the past three years, the air quality objective for PM_{10} was exceeded, on average, a minimum of 10% of the time at each of these sites. This corresponds to more than 5 weeks per year that the air quality was poor or very poor, without consideration of other air contaminants.
4. In contrast, few to no exceedances were reported for sites in southwestern BC.
5. PM_{10} levels at a number of sites in the province appear to be declining with time, although these changes were not tested for their statistical significance. Over the past

few years, improvements in both mean PM_{10} concentrations and exceedance frequencies have been noted in Port Alberni, Vernon and Golden.

6. However, in 100 Mile House and Prince George (BC Rail), PM_{10} levels appear to have remained the same or be increasing.
7. The number of $10\ \mu g/m^3$ increments of PM_{10} above a threshold level (i.e. the number of PM_{10} increments) can be used to estimate the potential for associated health effects due to PM_{10}. On an annual basis, the number of PM_{10} increments ranged from less than 10 to greater than 1000. The fact that increments were calculated for all sites in the province suggests that even those people living in communities with "good" air quality may be subject to an increased risk of PM_{10}-related health effects.
8. The highest PM_{10} concentrations were typically observed during the winter months, and in particular, in February and March. At sites in Victoria and the Lower Mainland / GVRD, peak concentrations were observed in January and September. Numerous factors may have contributed to these findings, including the prevailing meteorological conditions. However, it is noted that high wintertime values are consistent with contributions from space heating sources such as wood stoves and fireplaces. Elevated levels in March may also reflect local road dust problems resulting from the accumulation of salting and sanding materials over the course of the winter. Peak concentrations in September-October are consistent with contributions from backyard burning. However, more detailed studies would be required to determine the contributing source types.

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Appendix I:

PM_{10} Monitoring Locations in BC

Table I-1. Summary of PM_{10} sampler locations and status.

Region	Site Number	Site Name	Sample Type	Start Date	End Date	Status
Vancouver	0110030	Victoria	SSI	3-Apr-88	-	
Island	0110254	Port Alberni, Firehall	SSI	21-Oct-92	-	
(1)	0110263	Port Alberni, Auto Marine	SSI	1-Aug-88	20-Feb-95	CLOSED
	0110264	Port Alberni, Courthouse	SSI	6-Feb-85	-	
	E206378	Crofton, Compton Farm	SSI	27-Oct-92	2-Apr-94	CLOSED
	E206379	Crofton, Community Hall	SSI	27-Oct-92	8-Apr-94	CLOSED
	E216751	Harmac, Cedar Site At Nicholl's Farm	SSI	9-Jan-92	28-Dec-92	CLOSED
	E216752	Harmac, Canoxy Site	SSI	9-Jan-92	28-Dec-92	CLOSED
	E219361	Gold River	SSI	5-Aug-93	3-Nov-93	CLOSED
	E222520	Elk Falls Dogwood	TEOM	9-Dec-95	-	
Lower	0310172	Squamish	SSI	13-Dec-90	26-Mar-94	CLOSED
Mainland	0310172	Squamish	TEOM	11-Sep-94	-	
(2)	E206164	Horseshoe Bay, W Van Fire Hall No 2	SSI	20-Jun-87	31-Aug-88	CLOSED
	E206169	Pitt Meadows, Airport	SSI	17-Feb-91	-	
	E206612	Chilliwack, Works Yard	TEOM	2-Nov-94	28-Feb-95	CLOSED
	E207286	Powell River, Cranberry Centre	SSI	3-Jul-89	22-Feb-90	CLOSED
	E213114	Chilliwack, Mertins	SSI	1-Nov-90	8-May-94	CLOSED
	E214615	Hope, Firehall	SSI	25-Mar-91	-	
	E217029	Abbotsford, Library	SSI	6-May-92	16-Mar-95	CLOSED
	E217029	Abbotsford, Library	TEOM	19-Jul-94	-	
	E217255	Albion, Wasa Insurance Co.	SSI	29-Oct-94	29-Oct-94	CLOSED
	E217319	Albion, Elementary School	SSI	1-Jun-94	-	
	E217320	Mission, Pioneer	SSI	9-Dec-93	-	
	E220891	Chilliwack, Airport	SSI	19-Jun-94	22-Mar-95	CLOSED
	E220891	Chilliwack, Airport	TEOM	1-Mar-95	-	

Table I-1. Summary of PM_{10} sampler locations and status (continued).

Region	Site Number	Site Name	Sample Type	Start Date	End Date	Status
GVRD	0310162	Port Moody, Rocky Point Park (T9)	SSI	6-Mar-90	-	
(2)	0310162	Port Moody, Rocky Point Park (T9)	TEOM	1-Nov-93	-	
	0310175	Vancouver, Kitsilano (T2)	TEOM	13-Dec-93	-	
	0310175	Vancouver, Kitsilano (T2)	SSI	23-Jul-91	-	
	0310177	Burnaby, Kensington Park (T4)	TEOM	13-May-94	-	
		Vancouver, B.C. Hydro (T1a)	SSI	25-Sep-89	9-Dec-93	CLOSED
	E206271	Surrey East (T15)	TEOM	6-Jan-94	-	
	E207417	Richmond South (T17)	TEOM	27-Oct-93	-	
	E207418	Burnaby South (T18)	TEOM	29-Mar-94	-	
	E207723	North Delta: GVRD (T13)	TEOM	17-Dec-93	-	
	E209178	Langley Central (T27)	TEOM	1-Mar-95	-	
Southern Interior	0605001	Kamloops, Airport	SSI	5-Jan-90	12-Dec-93	CLOSED
(3)	0605096	Kamloops, BC Tel Valleyview	SSI	5-Jan-90	29-Apr-93	CLOSED
	E206725	Kamloops, Federal Building	SSI	10-Feb-90	-	
	E206898	Kamloops, Brocklehurst	SSI	5-Jan-90	28-Dec-94	CLOSED
	E206898	Kamloops, Brocklehurst	TEOM	1-Jan-94	-	
	E208083	Merritt, Schu	SSI	5-Jan-90	-	
	E208805	Westsyde, BC Tel	SSI	5-May-90	-	
Kootenay	0250009	Trail, Butler Park	SSI	23-Apr-90	-	
(4)	0250009	Trail, Butler Park	TEOM	11-Apr-94	-	
	0250182	Elkford	SSI	3-Feb-88	26-Mar-93	CLOSED
	0260104	Slocan, W.E. Graham School	SSI	8-Nov-91	-	
	E206241	Cranbrook, Amy Woodland School	SSI	19-Apr-85	31-Mar-91	CLOSED
	E206243	Cranbrook, Swimming Pool	SSI	12-Mar-90	-	
	E206243	Cranbrook, Swimming Pool	TEOM	1-May-92	16-Sep-93	CLOSED
	E206375	Nelson, Government Building	SSI	23-Apr-90	-	
	E206786	Skookumchuck, Bradford Ranch	SSI	30-Nov-89	30-Dec-89	CLOSED

Table I-1. Summary of PM_{10} sampler locations and status (continued).

Region	Site Number	Site Name	Sample Type	Start Date	End Date	Status
Kootenay	E206787	Fort Steele-Maus Creek, Kusy Residence	SSI	11-Nov-87	19-Mar-91	CLOSED
(4)	E206931	Castlegar Seniors	SSI	23-Apr-90	-	
	E207547	Kimberley, Marysville Post Office	SSI	21-May-88	4-May-89	CLOSED
	E207914	Skookumchuck, Johnson Lake	SSI	23-Apr-90	-	
	E213056	Creston, Hospital	SSI	20-Sep-90	-	
	E216700	Golden	SSI	21-Jan-92	-	
	E217680	Revelstoke, Firehall	SSI	6-Aug-93	-	
	E219639	Invermere, Bridgewater	SSI	30-Jul-93	27-Jan-94	CLOSED
	E220202	Invermere	SSI	9-Mar-94	-	
	E220203	Cranbrook, PR3	TEOM	20-Apr-94	-	
	E221080	Cranbrook, BC Environment Office	SSI	24-Aug-94	1-Sep-94	CLOSED
	E221199	Creston PC School	TEOM	27-Oct-94	-	
	E222142	Nakusp, High School	PARTISOL	6-Sep-95	-	
Cariboo	0550502	Williams Lake, NW Energy	TEOM	16-Dec-92	-	
(5)	0605020	Williams Lake, Skyline School	SSI	25-Mar-92	-	
	0605116	Williams Lake, Anne Stevenson Jr. Sec. School	SSI	20-May-87	6-Jan-88	CLOSED
	E206112	Williams Lake, Firehall	SSI	20-May-87	-	
	E206113	Quesnel, Firehall	SSI	1-Nov-90	8-Feb-95	CLOSED
	E208096	Quesnel, Senior Secondary School	TEOM	16-Apr-94	-	
	E213032	Quesnel, Pinecrest School	SSI	14-Oct-90	13-Mar-92	CLOSED
	E216667	Quesnel, Maple Drive	TEOM	24-May-95	-	
	E216730	Williams Lake, Golf And Tennis Club	SSI	22-Feb-92	21-Sep-93	CLOSED
	E216736	Williams Lake, Grisdale Residence	SSI	20-Feb-92	20-Feb-92	CLOSED
	E216754	Williams Lake, Ross Residence	SSI	26-Feb-92	26-Feb-92	CLOSED
	E216767	Williams Lake, Hodgson Residence	SSI	29-Feb-92	29-Feb-92	CLOSED
	E217364	Williams Lake, Glendale Garden Shop	SSI	18-Aug-92	26-Feb-93	CLOSED
	E218444	100 Mile House, B.C. Access Center	SSI	14-Mar-93	-	
	E221885	Quesnel, Pinecrest Centre	TEOM	9-Jun-95	-	
	E222242	Williams Lake, Water Tower	SSI	11-Nov-95	-	

Table I-1. Summary of PM_{10} sampler locations and status (continued).

Region	Site Number	Site Name	Sample Type	Start Date	End Date	Status
Skeena	0435079	Terrace, Firehall	SSI	22-Oct-93	-	
(6)	E206588	Smithers, ICBC Garage	SSI	16-Jul-90	15-Sep-91	CLOSED
	E206589	Smithers, St. Josephs	SSI	16-Jul-90	26-Apr-94	CLOSED
	E206589	Smithers, St. Josephs	TEOM	May-92	-	
	E216334	New Hazelton, 14th Avenue	SSI	2-Nov-91	24-May-92	CLOSED
	E218458	Houston, Silverthorne School	SSI	18-Feb-93	15-Jan-95	CLOSED
	E218578	New Hazelton, DFO	SSI	8-Mar-93	-	
	E219592	Burns Lake, Co Office	SSI	4-Oct-93	-	
	E221549	Houston, Firehall	TEOM	Sep-94	-	
		Terrace	TEOM			
		Kitimat	3 Partisols			
		Terrace	2 SSI			short-term
Omineca-	0450232	Prince George, Van Bien	SSI	3-Aug-90	-	
Peace	0450270	Prince George, Gladstone	SSI	23-Jun-92	-	
(7)	0450270	Prince George, Gladstone	TEOM	6-Dec-95	-	
	0450307	Prince George, Plaza 400	SSI	3-Aug-90	-	
	0450307	Prince George, Plaza 400	TEOM	1-Mar-92	-	
	0450324	Prince George, Lakewood	SSI	3-Aug-90	-	
	0450325	Prince George, Foreman Flats	SSI	3-Aug-90	30-May-92	CLOSED
	E218771	Prince George, CNRail	SSI	5-Jun-91	-	
	E218772	Prince George, BCRail	SSI	6-May-90	-	
		Chetwynd	SSI	9-Apr-94		
		Ft. St. James	SSI	9-Dec-93		
Southern Interior	0500827	Vernon, RCMP Bldg.	SSI	1-Oct-89	-	
Sub-Region	E222853	Vernon, City Hall	TEOM			mobile unit
(Okanagan)	0500869	Penticton, Airport	SSI	26-Nov-92	-	
(8)	0500886	Kelowna, Okanagan College	TEOM	22-Jan-94	-	
	E206302	Lumby, Home Furnishings	SSI	13-Apr-93	-	
	E206304	Kelowna, Okanagan College	SSI	1-Sep-89	-	
	E207520	Grand Forks, City Hall	SSI	16-Jul-92	-	